A Prospective Study of

FUNCTIONAL OUTCOME OF ANTEGRADE INTRAMEDULLARY INTERLOCKING NAILING IN FRACTURE SHAFT OF HUMERUS

Dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

CHENNAI – 600 032

In partial fulfillment of the regulations for the award of the

M.S. DEGREE BRANCH - II

ORTHOPAEDIC SURGERY

GOVERNMENT MOHAN KUMARAMANGALAM MEDICAL COLLEGE, SALEM

APRIL 2013

CERTIFICATE

This is to certify that **Dr. S.JAYAKRISHNAN**, Postgraduate student (2011-2013) in the department of Orthopaedics, Government Mohan Kumaramangalam Medical College, Salem has done this dissertation "***A Prospective Study of* FUNCTIONAL OUTCOME OF ANTEGRADE INTRAMEMEDULLARY INTERLOCKING NAILING IN FRACTURE SHAFT OF HUMERUS"** under my supervision in partial fulfillment of the regulation laid down by the Tamilnadu Dr. M.G.R Medical University, Chennai forM.S., (Orthopaedics) degree examination to be held during April 2013.

Prof.Dr.A.D.SAMPATHKUMAR
M.S. ORTHO,
Associated professor,
Department of Orthopaedics
Government Mohan Kumaramangalam
Medical College, Salem

Prof.Dr.C.KAMALANATHAN
M.S. ORTHO, D. ORTHO
Head of the Department,
Department of Orthopaedics
Government Mohan Kumaramangalam
Medical College, Salem

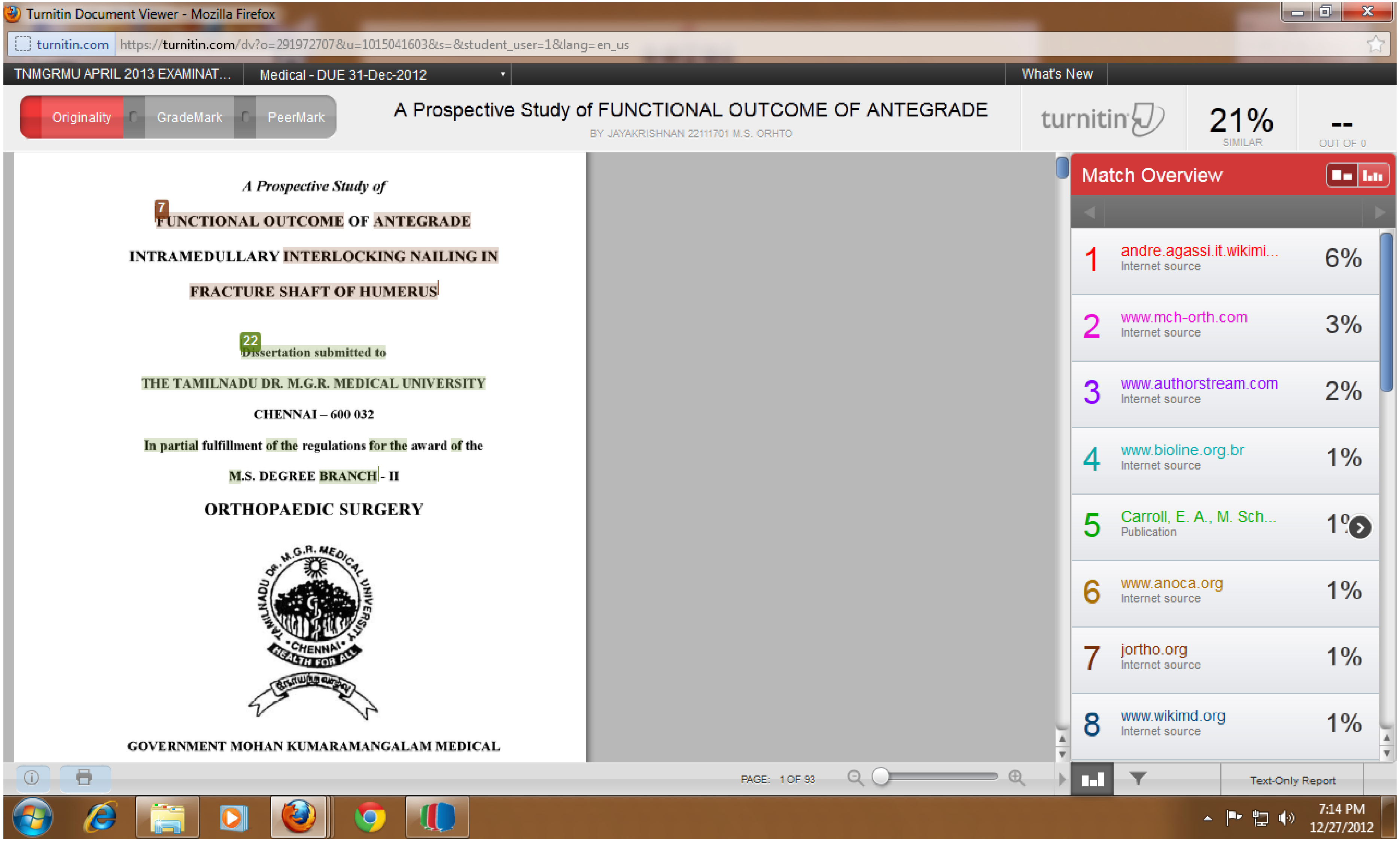
THE DEAN
Government Mohan Kumaramangalam
Medical College, Salem.

DECLARATION

I, **Dr. S. JAYAKRISHNAN**, solemnly declare that this dissertation titled "**A PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME OF ANTEGRADE INTRAMEDULLARY INTERLOCKING NAILING IN FRACTURE SHAFT OF HUMERUS**" is a bonafide work done by me, at Government Mohan Kumaramangalam Medical College, Salem between the period 2011-2013, under the guidance of my unit Chief **Prof. Dr.A.D. SAMPATH KUMAR M.S.(Ortho)**, Associate professor of Orthopaedic Surgery. This dissertation is submitted to Tamilnadu Dr. M.G.R Medical University, towards partial fulfillment of regulation for the award of M.S.Degree (Branch – II) in Orthopaedic Surgery.

PLACE: DR. S. JAYAKRISHNAN

DATE:


Turnitin Document Viewer - Mozilla Firefox
turnitin.com https://turnitin.com/dv?o=291972707&u=1015041603&s=&student_user=1&lang=en_us
TNMGRMU APRIL 2013 EXAMINAT...
Medical - DUE 31-Dec-2012
What's New
Originality
GradeMark
PeerMark
A Prospective Study of FUNCTIONAL OUTCOME OF ANTEGRADE
BY JAYAKRISHNAN 22111701 M.S. ORHTO
turnitin
21%
SIMILAR
--
OUT OF 0
A Prospective Study of
FUNCTIONAL OUTCOME OF ANTEGRADE
INTRAMEDULLARY INTERLOCKING NAILING IN
FRACTURE SHAFT OF HUMERUS
Dissertation submitted to
THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY
CHENNAI – 600 032
In partial fulfillment of the regulations for the award of the
M.S. DEGREE BRANCH - II
ORTHOPAEDIC SURGERY
GOVERNMENT MOHAN KUMARAMANGALAM MEDICAL
Match Overview
1 andre.agassi.it.wikimi... Internet source 6%
2 www.mch-orth.com Internet source 3%
3 www.authorstream.com Internet source 2%
4 www.bioline.org.br Internet source 1%
5 Carroll, E. A., M. Sch... Publication 1%
6 www.anoca.org Internet source 1%
7 jortho.org Internet source 1%
8 www.wikimd.org Internet source 1%
PAGE: 1 OF 93
Text-Only Report
7:14 PM
12/27/2012

ACKNOWLEDGEMENT

First and foremost, I would like to thank **Prof. Dr.R.VALLINAYAGAM**, Dean, Government Mohan Kumaramangalam Medical College, Salem for allowing me to use the available clinical resources and material of this hospital.

I acknowledge and express my humble gratitude and sincere thanks to **Prof. C.KAMALANATHAN, M.S. Ortho., D. Ortho.,** Professor and HOD, Department of Orthopaedics, Government Mohan Kumaramangalam Medical College, Salem for his supervision and help for this study.

I express my humble gratitude and sincere thanks to **Prof. Dr. A.D.SAMPATH KUMAR M.S. Ortho.,** for his valuable guidance and suggestions for this work. I acknowledge my gratitude to **Prof.Dr.M.ANTONY VIMALRAJ, M.S.(Ortho),** **Prof.Dr.R.T.PARTHASARATHY, M.S(Ortho),** **Prof.Dr.T.M.MANOHAR, M.S.(ORTHO),** **Prof.Dr.S.VEERAKUMAR, M.S(Ortho),** for their encouragement and help for this study.

I thank **Dr.T.Karikalan M.S(Ortho)**, Assistant Professor, Government Mohan Kumaramangalam Medical College and Hospital, Salem, for providing me his valuable thoughts and suggestions as a co-guide to perform and complete my dissertation.

I thank my Assistant Professors **Dr. M.Kannan M.S. (Ortho), Dr.S.Kumar, M.S.(Ortho), Dr.N.Karthikeyan M.S.(Ortho), Dr.P.Radhakrishnan, M.S.(Ortho), Dr.L.Kumar, M.S.(Ortho), Dr.G.Myilvahanan, M.S.(Ortho), Dr. ArunAnand, M.S.(Ortho), Dr.A.K.Tharun, M.S.(Ortho), Dr.T.SenthilKumar, D.Ortho, Dr.G.Sivakumar D.Ortho,**for their valuable guidelines and help. My thanks for their encouragement and opinions during the course of this study.

I thank the Anesthetists, staff members of the Operation Theatre and Radiology department for their cooperation during the entire period of study. I heartfully and gratefully thank my patients, who are my teachers throughout the period of this study, for their cooperation and patience. They provided me with enormous knowledge regarding the success, complications, problems, advantages and disadvantages of this method of treatment and helped me to improve in all the aspects, as a doctor and a human.

CONTENTS

INTRODUCTION

Fractures of the humeral shaft are relatively common injuries. The uniqueness in the anatomy, the fracture configuration and the functional significance of the region influences the treatment options.

Humeral shaft fractures account for approximately 3% of all fractures[3]. Nonsurgical management of humeral shaft fractures with functional bracing gained popularity in the 1970s, and this method is arguably the standard of care for these fractures. Still, surgical management is indicated in certain situations, including polytraumatic injuries, open fractures, vascular injury, ipsilateral articular fractures, floating elbow injuries, and fractures that fail nonsurgical management. Surgical options include external fixation, open reduction and internal fixation, minimally invasive percutaneous osteosynthesis, and antegrade or retrograde intramedullary nailing. Each of these techniques has advantages and disadvantages, and the rate of fracture union may vary based on the technique used. A relatively high incidence of radial nerve injury has been associated with surgical management of humeral shaft fractures[7]. However, good surgical outcomes can be achieved with proper patient selection.

The sleeve of muscles surrounding the bone and the rich vascularity provided by them helps in fracture healing. The mobility of the shoulder and the elbow joint accommodates for a minimal degree of angulation and shortening. Moreover the limb does not take part in weight bearing or ambulation; hence some amount of shortening is functionally acceptable.

Because of all these inherent advantages of the region, conservative treatment results in very gratifying outcome[23]. Treatment of humeral diaphyseal fractures has centred on nonoperative techniques, which have been providing excellent functional results. The main disadvantage of shoulder stiffness has been overcome by the functional bracing techniques.

Although most of these fractures can be treated nonoperatively, indications for operative intervention have been well reported. Ultimately, optimal results depend on matching the treatment alternative with the character of the fracture and the needs of the patient.

Open reduction and internal fixation with plate osteosynthesis supplemented with bone grafting has been the gold standard for treatment of fractures of the humeral diaphysis[32]. Though plate fixation has given high rates of union, it involves extensive soft tissue stripping, potential injury to radial nerve and poor fixation in osteoporotic bone.

Intramedullary fixation devices have been introduced as they have been used very effectively in the treatment of lower limb fractures. Interlocking intramedullary nailing is being evaluated for its effectiveness in the treatment of humeral diaphyseal fractures.

The advantages of intramedullary nailing are minimal surgical exposure, better biological fixation, and minimal disturbances of soft tissues and early mobilization of neighbouring joints[17]. The technique of interlocking nailing represents the newer approach of the treatment of humeral fractures. Interlocking nailing also avoids complications like lack of rotational control, migration of nail and requirement of supplementary bracing. Hence the method of Antegrade Interlocking nailing has got its own share of indications in properly selected patients without the usual complications which will be evaluated in detail in this study.

AIM OF THE STUDY

The aim is to prospectively study the "functional outcome of antegrade intramedullary interlocking nailing in fracture shaft of humerus" at the Department Of Orthopaedics and Traumatology,Government Mohan Kumaramangalam Medical College ,Salem.

HISTORICAL REVIEW

The treatment concept for these fractures has been evolving over the time period. Historically closed methods of treatment for humeral diaphyseal fractures have centred around one of the two principles

1. Thoraco brachial immobilization and
2. Dependency traction

Thoraco brachial immobilization involved use of the body as a splint. This was achieved by using body strapping or by shoulder arm spica application. This method of treatment was not reliable for maintaining the alignment of the bone and promotion of bone healing[18].

Caldwell promoted **Hanging arm cast** as a treatment option for management of humeral shaft fractures in 1933[7]. These are above elbow casts. They are stipulated to weigh less than 2lbs., in order to avoid distraction. These casts are provided with series of loops, which are used to correct angulation deformities.

U slabs or co-aptation splints were devised based on dependency traction. These are effective methods of treatment but functionally inferior to bracing.[7, 18, 19]

Treatment for humeral shaft fractures was revolutionized by the introduction of **functional bracing** by **Sarmiento**[41].This is a fracture treatmentorthosis made up of lightweight plastic brace fitted with Velcro straps. This has provided excellent long term results with 100% union rate with minimal complications of malalignment, infections, and iatrogenic nerve injury.[41]

Various studies have found bracing to be a much superior method of fracture treatment in an otherwise normal individual.[4, 8, 45]

Operative intervention was found necessary in patients with malalignment. **Klenermanet al**[20]**and Balfour et al**[2] in different studies found that a valgus angulation of more than 15° unacceptable cosmetically though they found that this was not having any functional disability.

Bell et alproposed that humerus fractures must be fixed in cases of polytrauma[3].**Brumback** suggested fixation for bilateral fractures of the humerus.[6]

Broad dynamic compression plate was promoted by **AO/ASIF** for fracture stabilization[40]. They noted complication rates of 7% hardware failure, 6% infection, and 5% chances of iatrogenic nerve palsy. This is still considered the gold standard of treatment of fractures of the humeral diaphysis.

Tingstad et alshowed that plating provides enough stability to allow early upper extremity weight bearing in polytrauma patients and produces minimal shoulder or elbow morbidity.

Kuntscher first proposed **Intramedullary nailing** for management of diaphyseal fractures of the femur, the tibia and the humerus during the World War II. This was further promoted by **Maatz.**[26]

Flexible nails in multiple numbers can be inserted into the humerus from both the ante grade and the retrograde entry portal. The nails which have been used are

1. Ender's nail[16, 23]
2. Hackethal nail[17, 33]
3. Rush nail[6]

They were found to be having good prognostic outcome with 3% chances of infection, 9 % chances of non-union, and rarely migration.[33]

Interlocking intramedullary nailing was the obvious sequel for this and the first nail to be introduced was the **Seidel's nail**[35]. The humeral intramedullary nails can be divided into

1. Expanding fin or interference fit e.g., the Seidel or Truflex nail,
2. Interlocking e.g., Russell-Taylor nail [Smith and Nephew] and
3. Compressing interlocking nail e.g., Synthes nail.

Reimer et al[35] reported a 58% complication rate in patients

undergoing Seidel humeral nailing when the humeral canal size was 9 mm or less, and postulated extensive reaming was one of the contributing factors.

Later distal locking is achieved by expandable fins, which are opened from within the barrel. This fell into disrepute because of the complications associatedwith the flange failure.[14]

Zimmerman and colleagues compared the biomechanical properties of distal fin locking nails (Seidel), solid interlocking nails, and flexible nails in cadaveric humerus with experimental transverse mid-shaft fractures.

When compared with plated humerus, the torsional properties of the solid interlocking nails were equivalent; however, solid interlocking nails offered greater bending rigidity and stiffness than plates.

Newer developments include the **MarchettiVicenzi nail[43], the Russel Taylor nail[10], Synthes nail.[5]** These nails are associated with less post operative shoulder function morbidity.

An antegrade approach is most commonly used for intramedullary nail fixation. Recently interlocking nailing has been promoted in the **retrograde insertion** technique to avoid the shoulder impingement syndrome.[43]

Also interlocking nailing has been found to be useful in the treatment of non union of fracture of the humerus[28], and pathological fractures of the humerus[13].

ANATOMY

The shoulder girdle includes three bones (the scapula, clavicle, and humerus) and three joints (the glenohumeral, acromioclavicular [AC], and sternoclavicular [SC] joints).

The scapulothoracic articulation is also considered part of the shoulder girdle. For every 2° of glenohumeral motion, approximately 1° of scapulothoracic motion occurs. The AC and SC joints also participate in this scapulohumeral rhythm. As a result of this coordinated movement, the shoulder has a greater range of motion than any other joint in the body.

The **humerus** is the longest and largest bone of the upper extremity; it is divisible into a **long tubular diaphysis, a globular proximal metaphysis and a flattened distal metaphysis.** The humerus consists of a large rounded head joined to the body by a constricted portion called the **neck,** and two eminences, the **greater** and **lesser tubercles.**

The Head (caput humeri) — the head, nearly hemispherical inform, is directed upward, medial ward, and a little backward, and articulates with the glenoid cavity of the scapula. The circumference of its articular surface is slightly constricted and is termed the **anatomical neck,** in contradistinction to a constriction below the tubercles called the **surgical neck** which is frequently the seat of fracture. Fracture of the anatomical neck rarely occurs.

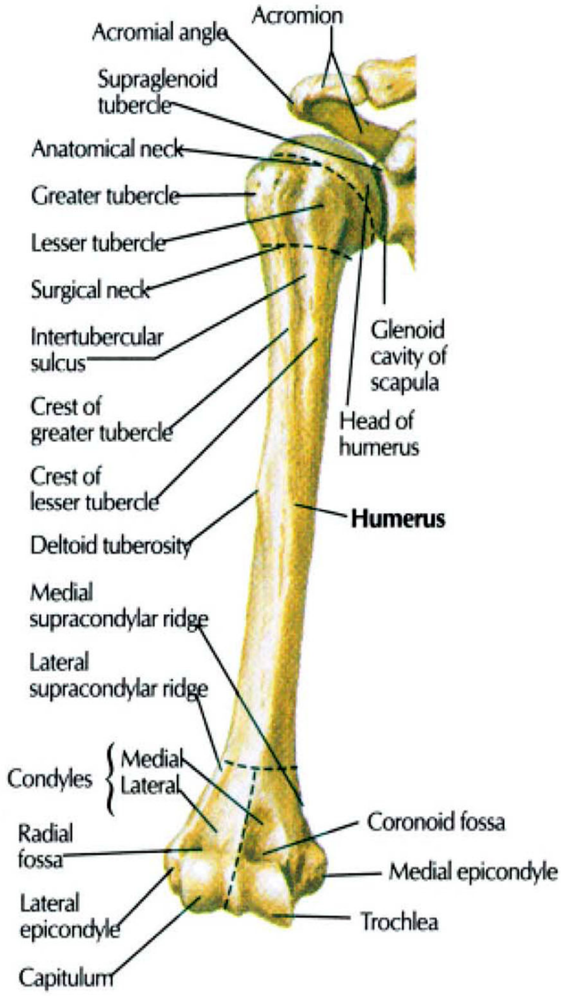
The Body or Shaft (corpus humeri) — the body is almost cylindrical in the upper half of its extent, prismatic and flattened below, and has three borders and three surfaces.

Borders — the **anterior border** runs from the front of the greater tubercle above to the coronoid fossa below, separating the anteromedial from the antero-lateral surface. Its upper part is a prominent ridge, the crest of the greater tubercle; it serves for the insertion of the tendon of thePectoralis major. About its centre it forms the anterior boundary of the deltoid tuberosity; below, it is smooth and rounded, affording attachment to the Brachialis.

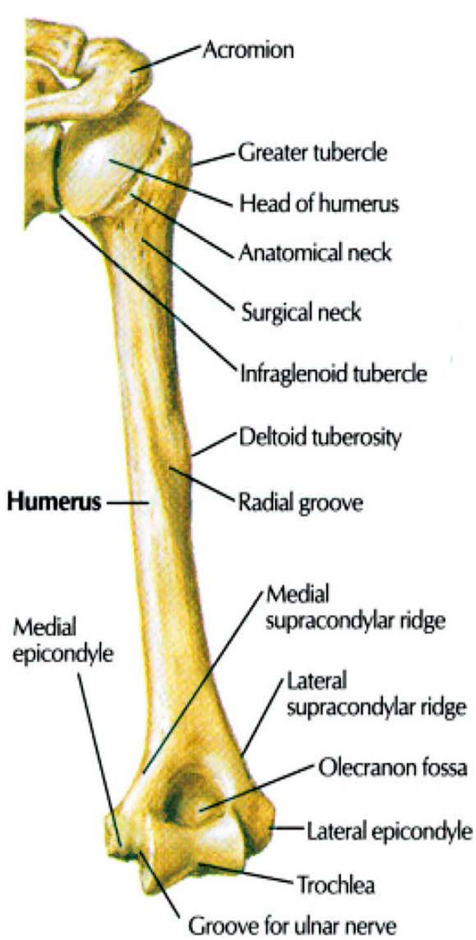
The **lateral border** runs from the back part of the greater tubercle to the lateral epicondyle, and separates the anterolateral from theposterior surface. Its upper half is rounded and indistinctly marked,serving for the attachment of the lower part of the insertion of the Teres minor, and below this giving origin to the lateral head of the Triceps brachii; its centre is traversed by a broad but shallow oblique

OSTEOLOGY

anterior view



posterior view



depression, the **radial sulcus** (musculospiral groove). Its lower part forms a prominent, rough margin, a little curved from behind forward, the **lateral supracondylar ridge,** which presents an anterior lip for the origin of the Brachioradialis above, and Extensor carpi radialislongus below, a posterior lip for the Triceps brachii, and an intermediate ridge for the attachment of the lateral intermuscular septum.

The **medial border** extends from the lesser tubercle to the medial epicondyle. Its upper third consists of a prominent ridge, the **crest of the lesser tubercle,** which gives insertion to the tendon of the Teres major. About its centre is a slight impression for the insertion of the Coracobrachialis, and just below this is the entrance of the nutrient canal, directed downward; sometimes there is a second nutrient canal at the commencement of the radial sulcus.

The inferior third of this border is raised into a slight ridge, the **medial supracondylar ridge,** which becomes very prominent below; it presents an anterior lip for the origins of the Brachialis and Pronator teres, a posterior lip for the medial head of the Triceps brachii, and an intermediate ridge for the attachment of the medial intermuscular septum.

Surfaces — The**antero-lateral surface** is directed lateralwardabove, where it is smooth, rounded, and covered by the Deltoid;forward and lateralward below, where it is slightly concave from above downward, and gives origin to part of the Brachialis. About the middle of this surface is a rough, triangular elevation, the **deltoid tuberosity** for the insertion of the Deltoid; below this is the **radial sulcus,** directed obliquely from behind, forward, and downward, and transmitting the radial nerve and profundabrachi artery.

The **antero-medial surface,** less extensive than the antero-lateral, is directed medial ward above, forward and medial ward below; it's upper part is narrow, and forms the floor of the intertubercular groove which gives insertion to the tendon of the Latissimusdorsi; its middle part is slightly rough for the attachment of some of the fibers of the tendon of insertion of the Coracobrachialis; its lower part is smooth, concave from above downward, and gives origin to the Brachialis.

The **posterior surface** appears somewhat twisted, so that its upper part is directed a little medial ward, its lower part backward and a little lateralward. Nearly the whole of this surface is covered by the lateral and medial heads of the Triceps brachii, the former arising above, the latter below the radial sulcus.

The Lower End — the lower end is flattened from before backward and curved slightly forward; it ends below in a broad, articular surface, which is divided into two parts by a slight ridge. Projecting on either side are the lateral and medial epicondyles. The **Articular surface** extends a little lower than the epicondyles, and is curved slightly forward; its medial extremity occupies a lower level than the lateral.

The lateral portion of this surface consists of a smooth, rounded eminence, named the **capitellum of the humerus;** it articulates with the cup-shaped depression on the head of the radius, and is limited to the front and lower part of the bone. On the medial side of this eminence is a shallow groove, in which is received the medial margin of the head of the radius. Above the front part of the capitellum is a slight depression, the **radial fossa,** which receives the anterior border of the head of the radius, when the forearm is flexed.

The medial portion of the articular surface is named the **trochlea,** and presents a deep depression between two well-marked borders; it is convex from before backward, concave from side to side, and occupies the anterior, lower, and posterior parts of the extremity. The lateral border separates it from the groove which articulates with the margin of the head of the radius.

The medial border is thicker, of greater length, and consequently more prominent, than the lateral. The grooved portion of the articular surface fits accurately within the semilunar notch of the ulna; it is broader and deeper on the posterior than on the anterior aspect of the bone, and is inclined obliquely downward and forward toward the

medial side.

Above the front part of the trochlea is a small depression, the **coronoid fossa,** which receives the coronoid process of the ulna during flexion of the forearm. Above the back part of the trochlea is a deep triangular depression, the **olecranon fossa,** in which the summit of the olecranon is received in extension of the forearm. These fossae are separated from one another by a thin, transparent lamina of bone, which is sometimes perforated by a **supratrochlear foramen;** they are lined in the fresh state by the synovial membrane of the elbow-joint, and their margins afford attachment to the anterior and posterior ligaments of this articulation.

Structure — The ends consist of cancellous tissue, covered with a thin, compact layer the body is composed of a cylinder of compact tissue, thicker at the centre than toward the extremities, and contains a large medullary canal which extends along its whole length.

In general all long bones have separate, anastamoticmetaphyseal and diaphyseal blood supplies. The diaphysis is supplied primarily by one or more nutrient arteries and an extra osseous soft tissue sleeve provide an abundant source of periosteal vessels that are concentrated around fascial attachments.

Two nutrient vessels supply the humerus. The humerus also has an abundant circumferential extra osseous soft tissue sleeve. Rhinelander[31] recognized the normal blood flow through the diaphyseal cortex of long bone as centrifugal, flowing through medulla to periosteum. He described three functional components of bone blood supply.

- Afferent vascular system carries nutrients and oxygen
- Efferent vascular system that carries the waste away from the bone

- Intermediate vascular system, which functions as the connectinglink between the afferent and efferent systems within cortical bone

Afferent vascular system has 3 components

- Nutrient artery system
- Metaphyseal arterioles
- Periosteal vessels

The principal nutrient artery, traverses the cortex of long bones, they enter the medullary cavity and divide into ascending and descending branches. They give rise to radially arrange lateral conduits which enter the endosteal surface of diaphyseal cortex and branch of into short segments of ascending and descending paraendosteal vessels that parallel the longitudinal axis of the long bone. The lateral conduit arteries and arterioles divide into ascending and descending bifurcations after entering into the surrounding osteon.

Periosteal arterioles supply the outer thirds of the cortex. Nutrientartery and periosteal arterioles are able to supplement each other if one of them is compromised.

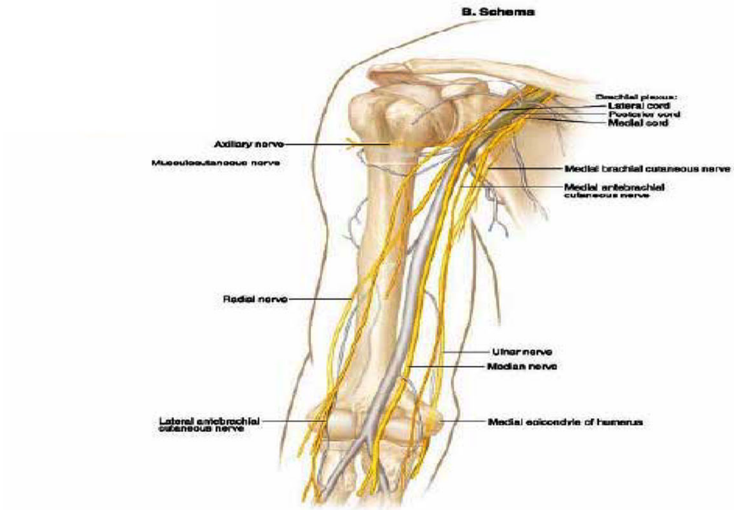
METAPHYSEAL CIRCULATION[8]

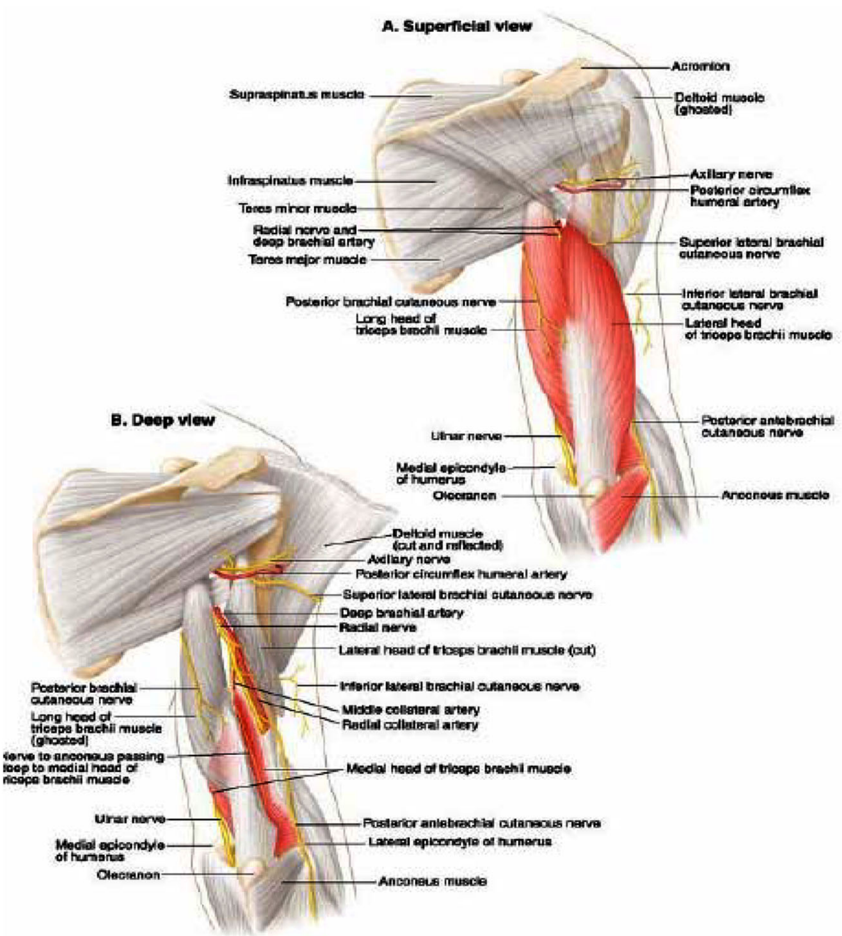
Metaphyseal circulation occurs through concentric arrangement of metaphyseal arteries which enter near the fascial attachments. Arterieswhich supply the joint may also give branches. They form an arcade which supplies the whole of metaphysis. These arteries give anastamotic channels to the nutrient artery thereby supplementing the cortical supply.

Three important neurovascular bundles flank the humerus in its anatomical relations. The axillary nerve runs around the proximal metaphysis of the humerus supplying the deltoid. It is about on an average 4.56cms from the lateral edge of the acromion. This is important while inserting the proximal locking screw. The brachial vessels, the median, the ulnar nerve and the medial cutaneous nerves of the arm and fore arm run in the space between the biceps and the brachialis.

Because the radial nerve can be injured during operative exposure and fixation of the humerus, it is essential for surgeons to understand its relationship with surgically identifiable landmarks. The radial nerve crosses the posterior aspect of the humerus in the radial groove flanked by the medial and the lateral head of the triceps starting approximately

NEURO VASCULAR RELATIONS





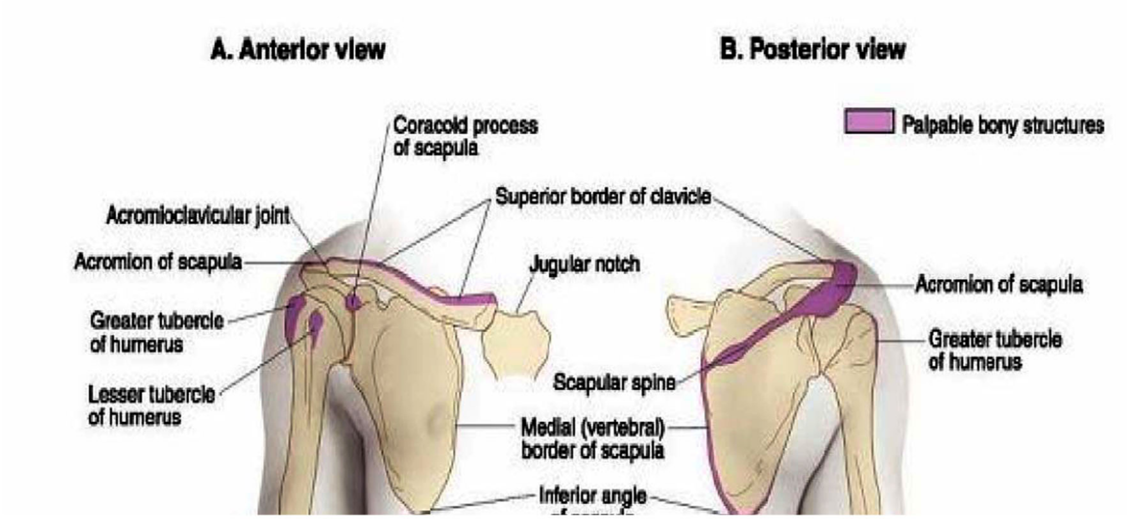
20 cm from the medial epicondyle to a point 14 cm from the lateral epicondyle. The nerve is in direct contact with the posterior aspect of the humerus for a length of approximately 6.5 cm. The nerve then pierces the lateral intermuscular septum to enter the anterior compartment. It then lies between the brachioradialis and brachialis muscles.

The medullary canal follows the contour of the humeral diaphysis. It is circular in its proximal half and is triangular in its distal half. It is broad proximally and tapers down distally. The medullary canal is straight and is having an anterior offset towards the distal end.

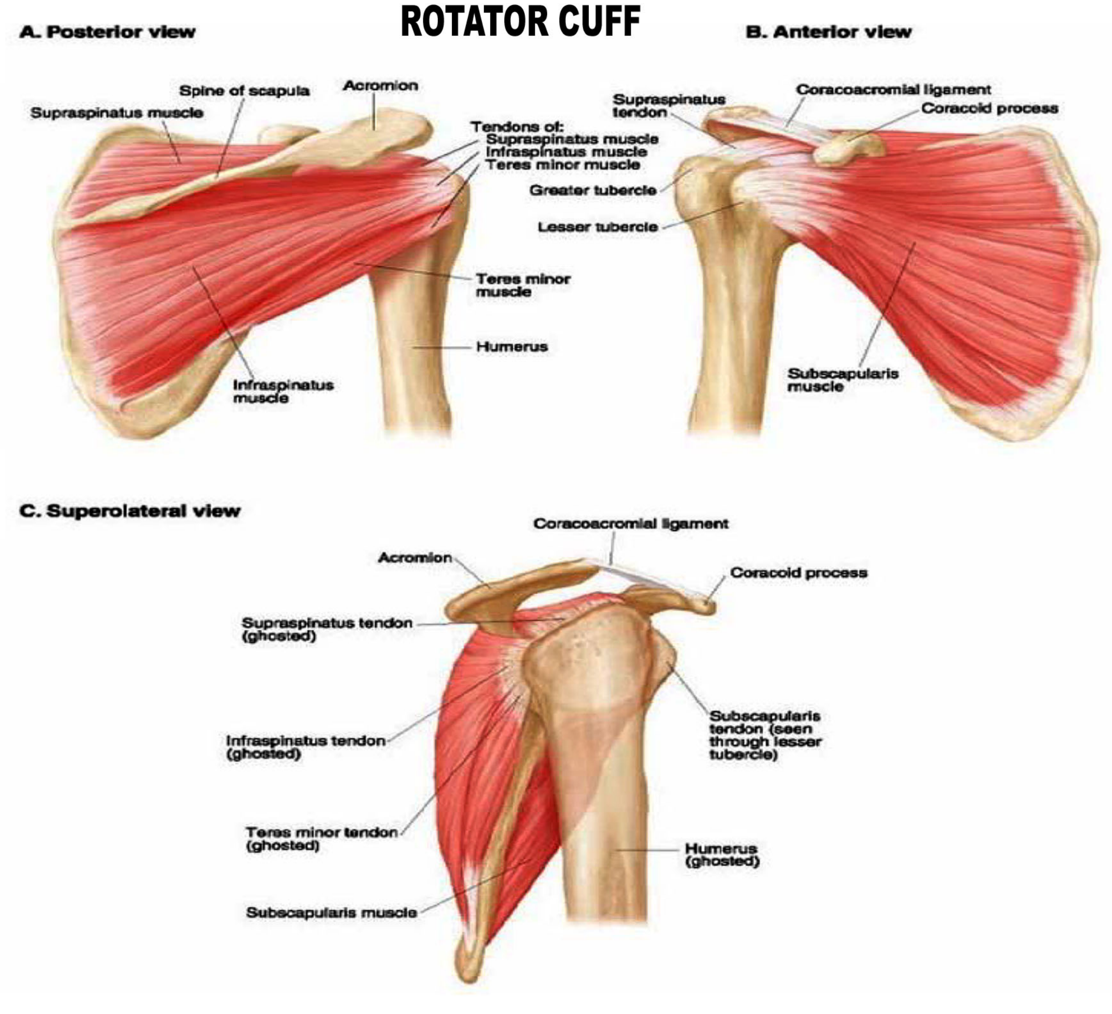
The fundamental difference seen in the intramedullary canal of the humerus and that of the tibia or femur is rather than having a capacious metaphyseal flare, the humeral canal tapers to an end above the olecranon fossa. Thus, the tip of the intramedullary implant ends in diaphyseal, rather than metaphyseal, bone.

ROTATOR CUFF:

The greater tuberosity has three regions into which the supraspinatus, infraspinatus, and teres minor gets inserted. Recognition of these three prominences may aid in determining the entry point for Interlocking nailing. The Supraspinatus tendon inserts into the greater



ROTATOR CUFF



tuberosity, the incision of which aids in identifying the correct starting point.

APPLIED SURGICAL ANATOMY

The entry point for humeral interlocking nail is very close to the passage of bicipital tendon, which may be irritated if, the nail projects out[14]. While exposing the entry point we have to dissect the rotator cuff, which has to be carefully repaired.

The entry point is intra articular and hence may be associated with shoulder stiffness. The axillary nerve runs at a distance of 4.56cms from the tip of the acromion[7]. It may be injured while applying the lower of the proximal locking screws.

The radial nerve runs very close to the middle two thirds of the bone in the radial groove. It may be injured by the fracture, during reduction, or during exposure by posterior approach.

The brachialis has a dual nerve supply by the musculo cutaneous nerve and the radial nerve. This fact is used while developing the plane during anterolateral approach.

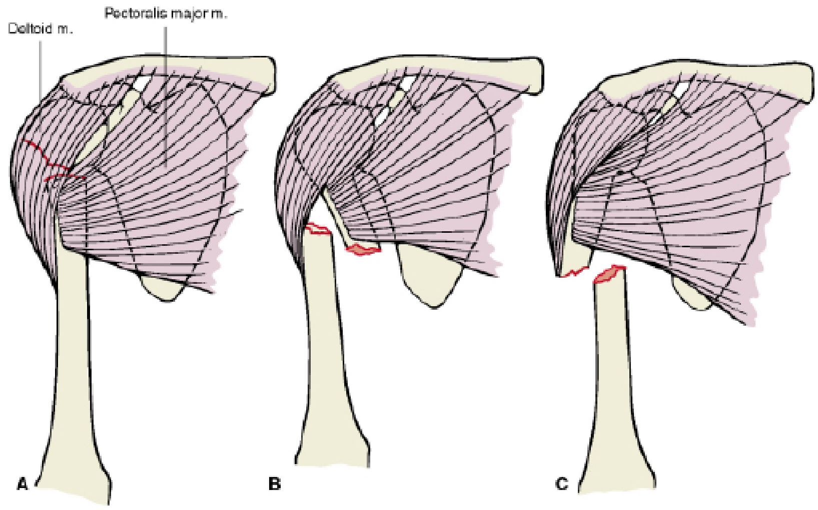
The canal is almost straight and the entry point is eccentric[11]. This determines the angle in the proximal end of the nail.

BIOMECHANICS

Fracture:

Analysis of fractures of the humeral diaphysis reveals the effect of muscular forces acting on the shaft at varying levels. In fractures occurring above the insertion of the pectoralis major, the proximal fragment is displaced into abduction and external rotation as a result of the action of the rotator cuff musculature. Fractures occurring in the interval between the insertion of the pectoralis major proximally and the deltoid insertion distally result in adduction of the proximal fragment and proximal and lateral displacement of the distal fragment. Fractures distal to the insertion of the deltoid muscle result in abduction of the upper fragment and proximal displacement of the distal fragment by unopposed muscle contraction.[32]

The energy absorbed by the humerus during a fracture is an important determinant of the amount of displacement. Low-energy fractures may be held in position by the internal splinting effect of the intermuscular septa. The weight of the arm aids in preserving alignment and length in these low-velocity injuries. High-energy fractures result in comminution of the bone and disruption of the soft tissues, with loss of this internal splinting effect.



A consideration other than location of the fracture and the amount of energy absorbed or dissipated in the injury is the mobility of the shoulder and the elbow joints, which tends to minimize the effect of post-traumatic angulation and rotational deformities. It has been shown experimentally that the musculature around the humerus will accommodate 20 ° of anterior angulation and 30 ° of varus angulation without compromising function or appearance. The normal mobility in the shoulder and elbow joints will compensate for this degree of deformity. The humerus can easily accept 15 ° of malrotation and still function fully. The amount of shortening that can be accepted in fractures of the humerus without loss of significant function is approximately 3 cm.

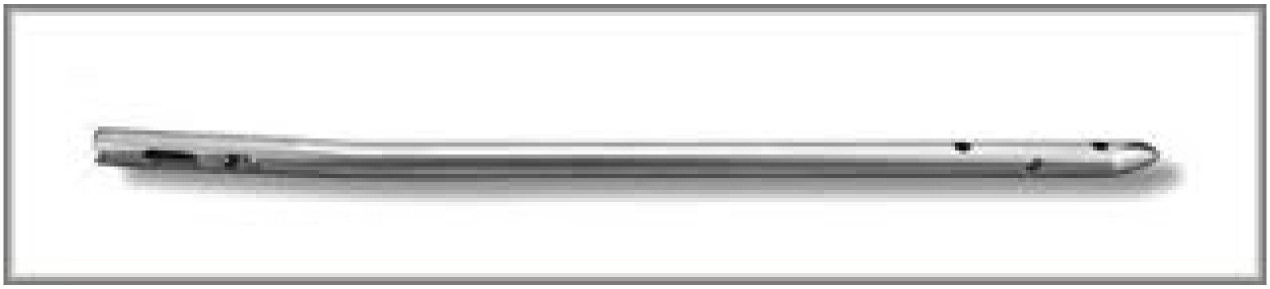
Implant:

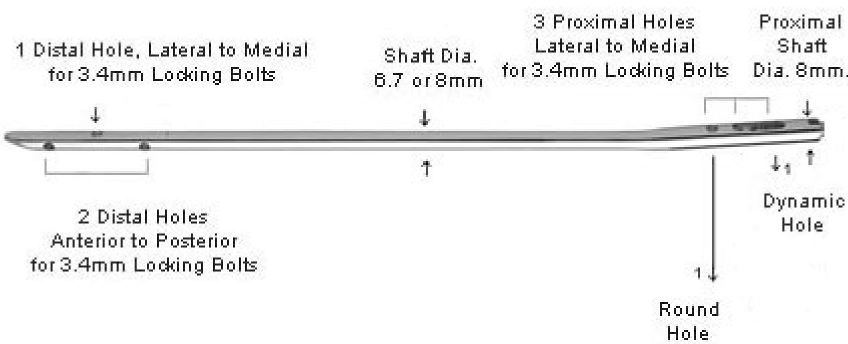
Kuntscher introduced the concept of elastic intramedullary nailing based on the principle of elastic impingement (i.e. radial compliance). The nail, which has a slot, could be compressed while insertion. The nail will expand and occupy the entire medullary canal, once the insertion is complete. This was used in fixation of the femur and tibia. Even though his concept was successful in treatment of the fractures of lower limb, it was found to be not effective in treating the humeral diaphyseal fractures. Further mechanical testing has shown that these nails are stable on the basis of three-point fixation rather than radial compliance.

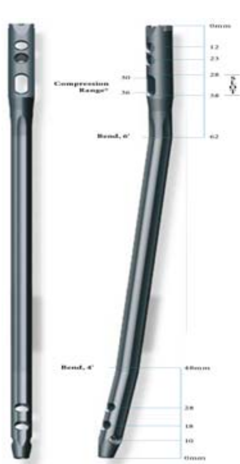
Significant deforming mechanical stress is exerted on the bone by the muscles getting attached on to it. These stresses may be bending stress, compression stress, rotational stress and distraction stress.

An intramedullary nail being located in the centre of the bone provides rigid temporary stiffness to the bone. It acts as an internal splint and works as a load-sharing device. Permitting load transmission across the fracture site and thus promoting fracture healing. These nails are best suited to control the bending and translational stresses. Since it shares the centre of rotation of the bone it is not effective in controlling

IMPLANT DESIGN







LOCKING BOLT

the rotational stress of the bone. This can be achieved by additional fixation likederotation plates, interlocking screws or pins.

The introduction of interlocking nail has made the use of unlocked nails obsolete. Screw insertion at the two ends of the humeral nail provides for the rotational stability by inter locking the nail with the proximal and the distal fragment. Inter locking essentially maintains the bone length and more importantly controls the rotational stability at the fracture site[1]. This is very significant in Humerus as the stresses are more of a rotational type rather than a compression distraction type. Static locking achieves a bridging fixation.

In bridging fixation the implant extends across the fracture site and is fixed to the major proximal and distal bone fragments by locking screws away from the fracture site.

NAIL DESIGN[44]:

The shape and diameter of the nail determines its bending and torsional strength. The diamond shape nail has greatest bending resistance. A clover leaf nail resists bending most effectively. The presence of slot does not reduce the bending stiffness of nail, but if reduce torsional stiffness. The hollow core, of the nail admits thick and strong guide wise that fills the space completely. So that nail remains centered in canal and passes smoothly into distal fragment across the fracture site.

DIAMETER:

The most important factor in determining nail strength is nail diameter. Strength is directly proportional to diameter. Bending rigidity is proportional is third power of nail diameter. Torsional rigidity is propositional to forth power of diameter.

CURVES[12]:

The long bone have curved medullary cavity. A straight nail is inserted in such a cavity; it will bend and produce stress and fracture of bone. So nails are contoured to accommodate the curves.

HOOP STRESS[44]:

Circumferential expansion of bone is called Hoop stress. The greater the insertion force the larger the hoop stress. Excess hoop stress can split the bone converting simple, transverse fracture into comminuted fracture. Flexible nail, over reaming the entry hole by 1 mm, selecting entry point post to central axis reduce insertion and hoop stress.

NAIL LENGTH AND WORKING LENGTH[44]

In working with interlocking nailing three lengths of the nail become significant

- Total nail length
- Length of nail bone contact
- Working length

Total nail length is purely anatomical. Too long a nail can protrude at the point of insertion and thus be intra articular. It may cause distraction at the fracture site and end up with non-union. Too short a nail length can compromise the fracture fixation.

The length of nail bone contact reflects the total surface area of contact between the nail and bone. This may provide for the rigidity of nail fixation.

Working length is the most crucial factor in determining the success of the fixation. It is defined as the length of the nail spanning the fracture site from its distal most point of fixation in the proximal fragment to the proximal most point of fixation in the distal fragment. This defines the length of bone carrying the load across the fracture site.

The bending stiffness of the nail is inversely proportional to square of its working length. While torsional is inversely proportional to its working length[6]. Shorter the working length stronger will be the fixation. Working length is affected by

1) Type of force
2) Type of fracture
3) Inter locking
4) Reaming

A nail fixing the transverse fracture has shorter working length than nail fixing the comminuted fracture. For torsional loads, when nail is fixed to the bone by interlocking screws, working length is equal to the definite points of fixation. Medullary reaming improves nail bone fixation thus reducing the working length.

LOCKING SCREWS

Strength of the locking screw depends upon the root diameter and the span of the screws between the support points. The screw ends are supported by the two cortices, while the longitudinal load is applied by the nail. Hence the locking screw is loaded at four points. Screws, which have threaded portion at one end and solid shaft at the other end, have a better strength. Obliquely oriented locking holes prevent mediolateral translation on varus valgus load.

Static locking

Static locking restricts translation and rotation at the fracture site. It is used in segmental fracture, comminuted fracture, long oblique and spiral fracture and fracture with bone loss.

Dynamic locking

When screws are inserted only at one end of the nail the fixation called dynamic locking is effective only when the contact area between the two major fragments is at least 50% of cortical circumference.

DYNAMISATION

Dynamization is indicated when the risk of development of non union or established pseudoarthrosis screws are removed from long fragment. It can be performed with 3rd month of treatment. It enhances fracture healing. Premature removal of locking screw may cause shorting, instability and non-union.

The closer the fracture to distal locking screw the nail has less cortical contact. This leads to increased stress on locking screw. More distal the locking screw is from fracture site, the fracture becomes more rotationally stable.

REAMING[36]

Reaming allows insertion of a larger diameter nail with a larger surface area and a more secure fixation. 1mm of reaming increase contact area by 38%.Reaming before nail insertion significantly increases muscle and surrounding soft tissue blood flow when compared with unreamed nails and that this increase persists for up to 6 weeks. An increase in blood flow to the soft tissues may also improve cortical blood flow. Studies have demonstrated increases in cortical blood flow up to five times control after reamed nailing.

Fracture site revascularization is possible by a number of ways, periosteal, endosteal or intracortical revascularization may occur. In addition a new and transitory extra osseous blood supply may be derived from the soft tissues surrounding the fracture, it serves to nourish the periosteal callus and detached fracture fragments.

Intramedullary reaming causes destruction of the contents of the marrow cavity. The medullary canal is irregular in both longitudinal and cross sections. For a stableintramedullary fixation a firm fit is needed. The process of reamingproduces a larger contact area between the nail and bone therebyincreases the stability of fixation. Reaming allows insertion of larger diameter stronger nail and reaming can stimulate fracture healing byproviding a source of autologous bone graft from the reamed particles at the fracture site[37].

Passage of a tight reamer in a tight medullary canal acts as a piston in a cylinder. Heat and hydraulic pressure are produced that destroys the endosteal surface and marrow contents. The amount of pressure that develops depends on the flow rate of medullary contents out of medullary cavity. Good reaming technique facilitates passage of the medullary contents out of the canal, prevents cortical temperature increase, and avoids significant increase in the medullary pressure.

To lower the pressure and temperature associated with reaming, Sharp cutting flutes must be used reamer heads should be designed to propagate, limit the amount of debris and disperse a large amount of medullary fluids. Long deep flutes facilitate passage of medullary contents. Flow rate is directly proportional while the increase in intramedullary pressure is inversely proportional to the diameter of the reamer and the diameter of the driver shaft.

Axial advancement should be slow with the reamer rotating at full speed. This reduces cortical necrosis and crack propagation. When any resistance is encountered reaming should be stopped, as the reamer advances the fracture site, the advancement and rotation speed are reduced to ensure that the fracture fragments are anatomically aligned to prevent eccentric reaming.

A distal vent can be used to remove the cavity pressure. However the viscosity of the medullary contents determines their ability to passthrough the hole.

High intramedullary pressure forces the medullary contents into general circulation which can lead to pulmonary micro embolism and circulatory dysfunction[44].Medullary contents can get entrapped in the cortical wall which can slow down the revascularization of the cortical bone and disturb healing.

Biomechanically reamed nail provides better fixation stability then do unreamed nail.

Reamed Nails[37]

Advantages

- Allows use of larger size implant
- Allows better nail bone interface
- Reamed material has osteogenic potential
- Morcellised bone fragments promote bony union

Disadvantages

- More chances of splintering
- Loss of endosteal blood supply
- Increase risk of fat embolism
- Higher infection rate
- Need for cannulated reamers

Unreamed nails[22, 28]

Advantages

- Lesser operating time
- Lesser disruption of endosteal blood supply
- Lesser infection rate
- Lesser chances of disruption of fragment comminution

DISADVANTAGES

- Smaller size nail only can be used

CLOSED AND OPEN NAILING

A nail can be inserted by closed or open method. In closed method fluoroscopy is used to achieve the reduction. Antegrade closed nailing is performed to minimize soft tissue trauma, maintains periosteal vascular supply and reduce the risk of infection. Incarceration of small comminuted cortical fragment and failure to obtain satisfactory reduction are the two clinical situations indicated to expose the fracture site. In open nailing the incidence of infection and non-union is respectively six and ten times greater than closed nailing.

The advantages of closed intramedullary nailing of diaphyseal fracture include are[19]

1. Preservation of fracture exudate:

   The exudate produced at the fracture site is very important for healing. It contains prostaglandins, various growth factors, bone morphogenetic proteins (BMP) and hyaluronates. All these and many unknown factors take part in the stimulation, formation and maturation of. This is all lost once the fracture site is opened and the exudate drained.

2. Stability of fracture reduction:

   The medullary canal is closer to the mechanical axis than the usual late position on the external surface of bone. Thus intramedullary nails are subjected to smaller bending loads than plates and are less likely to fail by fatigue. Further, stabilization leads to increased vasculatisation of the fracture ends and faster healing.

3. Preservation of vascularity:

   The periosteal blood supply is Undisturbedandendosteal circulation recovers at the earliest. In comminuted fractures, it provides a biological fixation by preserving the soft tissue attachments of bone.

4. Minimal risk of infection due to the shortened operative time and minimal incision, the risk of infection is much less compared to open procedures.

5. Allows early mobilisation of the limb with advantages of improved blood supply to the limb, aiding in faster fracture healing with a negligible risk of joint stiffness and muscle wasting.
6. Refracture after implant removal is rare with the use of Intramedullarynails, secondary to the lack of cortical osteopenia and since fewer stress risers are created.

With the increasing popularity of retrograde humeral nailing, the appropriate use of it is based on biomechanical parameters. In distal humeral shaft fractures, retrograde nails have shown significantly more initial stability and higher bending and torsional stiffness than is the case with antegrade nails[43]. The opposite has been observed in proximal humeral shaft fractures: antegrade nails demonstrated clearly superior biomechanical properties. As might be expected, both antegrade and retrograde nails have exhibited similar properties in mid-shaft humeral fractures. The significantly greater torsional resistance in the unreamed nail is attributed to its nail-bolt interface (circular holes versus slots).

Mechanically, intramedullary nails offer several advantages over plates and external fixators[9]. Intramedullary nails are subjected to smaller bending loads than plates because they are closer to the mechanical axis than the usual plate position on the external surface of the bone. Intramedullary nails can also act as load-sharing devices in fractures with cortical contact. Moreover, the stress shielding commonly seen with plates and screws is minimized with intramedullary nails. When compared with plated humerus, the torsional properties of the solid interlocking nails were equivalent; however, solid interlocking nails offered greater bending rigidity and stiffness than plates did. Moreover, solid interlocking nails had significantly greater torsional and bending strength than did either the distal fin or flexible nail constructs.

MATERIAL PROPERTIES[34]

The material used should be biocompatible to withstand corrosion and of sufficient strength to withstand the stresses. Material properties depend upon the composition of the material, the processing involved, the grain size and the porosity. Different materials have different elastic modulus thus with different tensile strengths. The best suited for fracture fixation being 316L stainless steel and titanium alloy.

316L Stainless steel is composed of iron, 17% chromium, and 12% nickel, 3% manganese and 2% molybdenum with <0.03% carbon. It has got excellent corrosion resistance. It has a modulus of elasticity comparable to human bone. Titanium alloy is made up of a composite of titanium, aluminium and vanadium. This has got the modulus of elasticity closest to the human bone but is very much corrosion resistant due to the property of formation of oxide film. It has an excellent resistance to fatigue due to cyclical loading.

CLASSIFICATION

Anatomic Location

1. Above the pectoralis major insertion
2. Below the pectoralis major insertion, above the deltoid insertion
3. Below the deltoid insertion

Fracture Personality (direction and character of the fracture)

1. Transverse
2. Oblique
3. Spiral
4. Segmental
5. Comminuted

Associated soft tissue injury

Gustilo Anderson Classification

1. Grade I
2. Grade II
3. Grade III A, B , C

Associated soft tissue injuries may dictate the mode of treatment. Gustilo grade I (low energy, wound <1 cm) and grade II (moderate energy and soft tissue damage, wound >1 cm) open fractures respond well to stable internal fixation and soft tissue care, whereas grade III (high energy, wound >10 cm) injuries may call for external fixation. Open injuries with associated nerve or vascular damage may require stabilization to protect the repair of these structures.

Spiral fractures in the distal third (Holstein-Lewis fracture) may produce a radial nerve injury.

The AO classification[33] is a well-accepted anatomic classification scheme for humeral shaft fractures. Briefly, fractures are categorized as simple (type A), wedge (type B), or complex (type C). Each of these types is further subcategorized to refine the anatomic nature of the fracture. In general, types A, B, and C represent a spectrum of increasing fracture severity. There are no classifications for humeral diaphyseal fractures good enough to prognosticate the outcome of the treatment. This AO/ASIF comprehensive classification system is of prognostic value, in that the greater the grade of fractures, the higher the energy of injury implying greater the chances of occurrence of complications during treatment.

AO/ASIF CLASSIFICATION OF THE HUMERAL DIAPHYSEAL FRACTURES

TYPE A: simple fractures.

Circumferential break in the bone

A1. = Spiral fractures

1. In the proximal zone
2. In the middle zone
3. In the distal zone

A2. = Oblique fractures fracture lies at 30° or more to the diaphysis.

1. In the proximal zone
2. In the middle zone
3. In the distal zone

A3. = Transverse fractures fracture lies at <30° to the diaphysis

1. In the proximal zone
2. In the middle zone
3. In the distal zone

TYPE B: Wedge fractures.

Separate butterfly fragment but the fracture reduces with contact between the main fracture fragments

B1 = spiral wedge as a result of torsional forces.

1. In the proximal zone
2. In the middle zone
3. In the distal zone

B2 = bending wedge as a result of bending stresses.

1. In the proximal zone
2. In the middle zone
3. In the distal zone

B3 = bending wedge where the wedge is comminuted

1. In the proximal zone
2. In the middle zone
3. In the distal zone

TYPE C: complex fractures.

There are more than two fragments, and even after reduction the two main fragments do not come in contact.

C1 = spiral

1. Two intermediate fragments
2. With three intermediate fragments
3. With more than three intermediate fragments

C2 = segmental

1 .With one intermediate segment

2 .With one intermediate segment and a butterfly Fragment

3.With two intermediate segment

C3 = irregular fractures

1 .With 2 or 3 intermediate fragments.

2 .With shattering of the bone for a length of less than 4cms.

3 .With shattering of the bone for a length of more than 4cms.

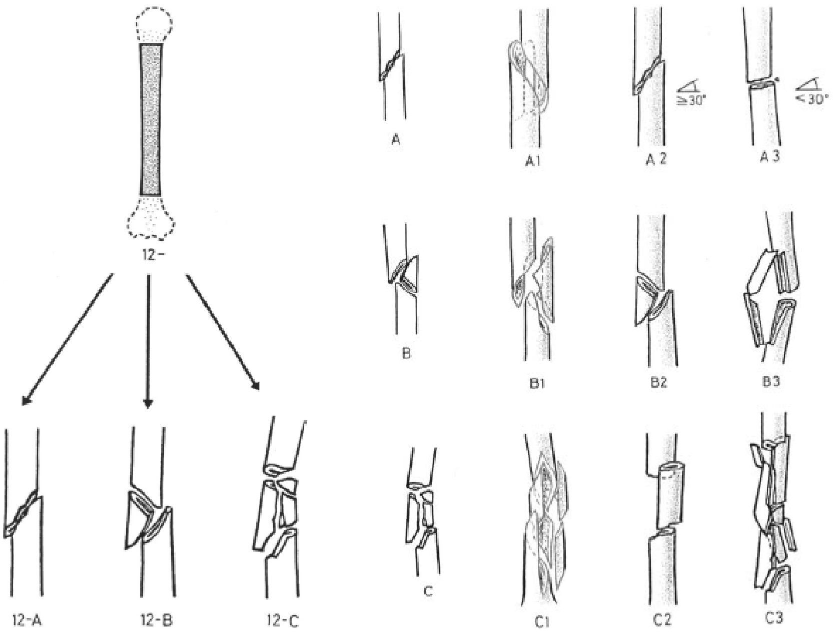
AO CLASSIFICATION

Bone = humerus = 1
Segment = diaphysis = 2
Groups = A/B/C where

A: Simple fracture
B: Wedge fracture
C: Complex fracture

Subgroups:

A1: Simple fracture, spiral
A2: Simple fracture, oblique ($\geq$30°)
A3: Simple fracture, transverse (<30°)
B1: Wedge fracture, spiral wedge
B2: Wedge fracture, bending wedge
B3: Wedge fracture, fragmented wedge
C1: Complex fracture, spiral
C2: Complex fracture, segmental
C3: Complex fracture, irregular



MATERIALS AND METHODS

Our study is a case series of 20 diaphyseal fractures in 20 persons treated with Antegrade Intramedullary Interlocking nailing. This was conducted from June 2011 to November 2012

INCLUSION CRITERIA

Our patients were selected based upon following criteria

1. Closed fracture shaft of humerus
2. Grade I and II compound fractures
3. An angulation of more than 15° after closed reduction
4. Associated neurovascular compromise
5. Poly trauma
6. Age more than 17 years when the physis is fused
7. The fracture line is 3 cms beyond the surgical neck of the humerus and 4 cms proximal to the tip of the olecranon fossa.

EXCLUSION CRITERIA

1. Presence of open physis

2. Grade II and Grade III compound fractures

3. Fracture involving the proximal 3cms. and the distal 4cm of humerus.

HISTORY

Humeral shaft fractures typically result from falls, twisting injuries, penetrating injuries, and pedestrian or motor vehicle crashes. In a poly trauma patient, the history is infrequently available from the patient because of the patient's medical condition and associated injuries. In such situations, delineating the mechanism of injury provides important clues to the nature of the patient's injuries[22].

In addition to the mechanism of injury, information pertaining to co-morbidities such as previous neurologic injury, metabolic bone disease, malignancy, or lower extremity injuries (requiring use of the upper extremities for ambulation) should be obtained from either the patient or family members[16].

PHYSICAL EXAMINATION

In general, the treatment of a humeral fracture is a relatively low priority in the resuscitation of a severely injured patient, which should proceed according to the guidelines of the Advanced Trauma Life Support (ATLS) protocol[42]. Following stabilization of the patient, attention is turned to the affected arm.

The neurovascular status of the entire limb should be evaluated at multiple levels. Careful motor and sensory examination of the radial, ulnar, and median nerves is essential. A careful clinical examination is the most useful way to follow a radial nerve injury. Attention should be directed to motor function in the brachioradialis and extensor carpi radialislongus muscles. Electromyography and nerve conduction studies may also be used to follow the recovery of injured radial nerves[27]. However, these studies reveal nerve recovery only, at most, 1 month before it is detectable by clinical examination. In addition, they cannot identify severed nerves.

The soft tissue compartments of the arm and forearm should be examined, and the possibility of a compartment syndrome should be considered.

The shoulder and elbow joints should be carefully evaluated. Abrasions, lacerations, or puncture wounds on the arm should raise suspicion of an open injury necessitating emergency management.

INVESTIGATIONS

Routine investigations like Haemogram, Blood Sugar, Urea, Creatinine, Serum electrolytes, X-Ray Chest, ECG, BT/CT was done. All the patients were medically fit for anaesthesia and surgery.

Radiographic Evaluation:

Standard radiographic evaluation of the humerus should include two views taken at 90° to one another, with the shoulder and elbow joints included in each view[35].Advanced imaging such as CTis rarely necessary for humeral shaft fractures.

It is necessary to carefully examine preoperative radiographs of the involved humerus and assess the canal diameter to decide on the treatment option and avoid any devastating complication in the aftermath.

In pathologic fractures, other studies such as technetium-labelled bone scans, computed tomography (CT) scans, and magnetic resonance images are often necessary to delineate the extent of disease.

Lambotte's principles of surgical treatment of fractures were used in all our cases[32].

1. Anatomical reduction especially in joint fractures
2. Stable internal fixation to fulfil local biomechanical demands
3. Preservation of blood supply to the injured extremity
4. Active pain free mobilization of the limb to prevent the development of joint disease.

PREOPERATIVE PLANNING

Several variables must be considered before formulating a treatment plan. The fracture pattern, degree of soft tissue injury, associated neurologic injury, patient age, co-morbidity, and patient compliance should be considered together to optimize treatment success and limit the risk of complications[28]. In all cases, fracture management is combined with early motion and rehabilitation of the injured extremity to limit problems associated with immobilization.

The nail size is measured from the radiograph of the normal bone. It is measured between the tip of the greater tuberosity to a point 3cms proximal to the tip of the olecranon fossa. The best method is by use of a scanogram where the nail of approximate length is tied to the normal arm and a radiograph is taken[20].

Accurate assessment of canal diameter is imperative in the preoperative plan for the following reasons: (1) the humerus does not tolerate reaming well, (2) some nails are available in only one size and (3) excessive reaming may have potential drawbacks (i.e., cortical necrosis), and certain types of nails are more prone to complications when small-diameter nails are used[7]. In spite of the pre operative planning we have to keep ready the whole range of the nail system.

IMPLANT DESIGN

Humerus interlocking nail used by us was made of stainless steel316L. They are available in diameters of 6.0mm that are non annulated solid nails and the 7.0mm annulated nails. They can be inserted over 2.4mm thick guide wire.

The nails are available in various lengths startingfrom 160 mm onwards at increments of 10mm. The distal end is blunt and bevelled to allow easy negotiation of the nail. The nails have an internalthread in the proximal end to accommodate the locking nut in the jig.

The proximal end is broadened to accommodate thicker screws. Three circular static slots are provided for locking. The proximal locking is providedfrom lateral to medial direction.

The distal locking for the 6.0mm solidnails are 2 in number and both are static. The distal locking for the 7.0mmcannulated nails are 2 in number the proximal being dynamic and thedistal static. The distal locking are in the anteroposterior direction. The locking screws are self tapping cortical screws. The distal locking can be done both through the jig and image intensifier.

SURGICAL PROCEDURE

Position

The patient is placed on a beach chair or similar reclining support. The patient is then brought to the edge of the radiolucent table and a roll placed underneath the scapula. The shoulder should easily extend to 30° to expose the humeral head from beneath the acromion.

The C-arm may be positioned in one of three ways most convenience: (1) on the unaffected side of the patient, (2) at the head of the patient with the C-arm moved parallel to the humerus, or (3) perpendicular to the patient on the affected side with the swing of the C-arm in line with the patient[12]. The arm is prepared and draped free in the sterile field. Anteroposterior views of the humerus are obtained with the arm anatomically positioned. Gentle rotation can also be used to project a lateral view. A graduated ruler may be positioned on the arm to determine the appropriate length of nail required.

Approach:

The antegrade approach is commonly used for fractures involving the proximal and middle thirds of the humerus; however, distal third fractures can also be treated with antegrade humeral nails.

The incision is typically made anterolateral to the acromion[29]. Lateral or posterior placement of the incision increases the risk of fracture of the proximal end of the humerus on nail insertion.

A deltoid-splitting approach is used, and the subdeltoid bursa is exposed and excised to visualize the supraspinatus tendon. The deltoid should not be incised farther than 4 to 5 cm distally to avoid injury to the axillary nerve. The supraspinatus tendon is incised in line with its fibers with the arm adducted and flexed across the chest.

The entry portal is based just medial to the greater tuberosity. The potential drawback with a lateral portal is that the lack of linear access to the humeral canal necessitates additional medial tearing of the rotator cuff as the nail is inserted[38]. This can be seen per operatively as a depression of the anatomical neck. The entry point can also be checked by image intensifier.

After nail placement, care must be taken to repair the supraspinatus tendon. The incision for the distal locking screws is based lateral to the biceps tendon. The tendon is retracted medially, with care taken to protect the branches of the lateral antebrachial cutaneous nerve. Injury to the anterior interosseous nerve may also occur during anteroposterior insertion of distal interlocking screws in the antegradeapproach. These injuries are usually transient and resolve in a period of weeks to months.

Reduction

Fracture reduction can be accomplished with gentle longitudinal traction and manual manipulation[38]. However, excessive traction and manipulation increase the risk of neurologic injury.

Entry portal

Through the image intensifier the entry point which is just medial to the greater tuberosity and in the area at junction between the articular surface of the head and greater tuberosity is marked with k wire.An awl is introduced over a previously marked K wire site. This starting position is directly in line with the intramedullary canal but should be confirmed by fluoroscopy[4].

Reaming

Intramedullary reaming can be used to facilitate insertion of the selected nail. This prevents the development of hoop stresses at the entry point while insertion of the nail. When reaming is chosen, it must be ensured that cortical contact at the fracture site is achieved before passage of the reamer. Cortical fracture gaps place the radial nerve at risk of injury when the reamer is passed across the fracture. Unreamed nails must be passed by hand or very gentle tapping.

However frequently reaming before nail insertion significantly increases muscle and surrounding soft tissue blood flow when compared with unreamed nails and that this increase persists for up to 6 weeks. An increase in blood flow to the soft tissues may also improve cortical blood flow[6]. Studies have demonstrated increases in cortical blood flow up to five times control after reamed nailing.

The degree of reaming may also be important in optimizing patient outcomes. Also in fractures that compromised circulation (i.e., segmental fractures), limited reaming led to the smallest degree of cortical porosity when compared with standard reaming or controls.

Nailing

The nail whose dimensions have been determined by pre operative radiographs is mounted on to a jig. The size of the nail can be reconfirmed by using a guide pin and checking under an image intensifier. The nail mounted on to the jig is inserted through the entry point into the bone.

At the fracture site it is negotiated across the fracture ends with the guidance of the image intensifier. The nail can be tapped in order to push it deep into the Humerus so that it does not protrude into the articular surface. Because distraction of the fracture is a potential risk during nail insertion, care must be taken to ensure that the fracture is reduced. Compression can also be facilitated through the nail.

The humeral nail selected is usually 6 to 8 mm in diameter[14]. Young patients often have a smaller-diameter intramedullary canal that requires reaming before nail placement; in older patients with a larger-diameter intramedullary canal, an unreamed 9-mm humeral nail can often be used.

Proximal nail care

It is important to ensure that the proximal end of the nail is buried within the substance of the humeral head to limit shoulder impingement.

Locking screws

Distal fixation can be achieved by interlocking screws or interference fit. To ensure rotational stability, screw fixation is recommended at each end of the nail to control rotation.

Under image guidance the location of the distal locking slot is noted and a stab Incision is made on the anterior aspect of the arm. Both the biceps and the brachialis are split to reach the anterior surface of the Humerus. Under image control, the bone is drilled using 2.9mm drill bit and distal locking is achieved using 3.9mm screw passed anteroposteriorly for 7mm nail and 2.5 drill bit, 2.9mm screw used for 6mm nail.. Distal locking can also be achieved by using a distal locking jig.

In contrast to the laterally based distal locking screw fixation in femoral and tibial nailing, humeral nails are distally locked in either a posterior-to-anterior (safest in terms of nerve proximity), anterior-to-posterior, or lateral-to-medial direction[40]; however, the difficulty in placing most multiply injured patients in the prone position limits use of the posterior-to-anterior approach.

When the lateral approach is used, care must be taken to use blunt dissection to bone to ensure that the radial nerve is away from the drill. The fracture site can be compressed by back slapping the nail after insertion of the distal locking screw.

The Proximal locking is achieved by using 3.9 mm self-tapping locking screws. This is applied by using the jig and the screw is passed lateral to medial. Care has to be taken to avoid the axillary nerve, which is situated on an average 4.56cms distal to the acromion[11]. The screw slot can be predrilled with 2.9mm drill bit.

The rotator cuff has to be repaired using a non-absorbable suture. All the wounds are closed in layers. Suction drain must be kept inside the shoulder joint[20].

POST OPERATIVE TREATMENT

Intramedullary interlocking nailing is done with the aim of providing early active mobilization of the limb. Drain tube is removed 48-72 hrs after the surgery. Antibiotics are given up to the fifth postoperative day.

Patient is taught passive and active range of motion exercises and he is made to perform the same as the pain permits. This includes pendular motion exercises and the supported and active abduction exercises involving the shoulder and flexion exercises involving the elbow. Progressive increasing weight bearing can be promoted with time.

Serial radiographs are taken at monthly intervals in two perpendicular planes to note for the fracture union.

FOLLOWUP ASSESSMENT

RODRIGUEZ MERCHAN CRITERIA[32]

As in most studies of humeral shaft fractures, in this study fracture union, shoulder joint function, and complication and reoperation rates were used as outcome criteria. In a series of radiographs, absence of signs of union 6 months after the injury is generally regarded as nonunion.

RATING	**ELBOW ROM**	**SHOULDER ROM**	**PAIN**	**DISABILITY**
EXCELLENT	EXTENTION 5 FLEXION 130	FULL ROM	NONE	NONE
GOOD	EXTENTION 15 FLEXION 120	<10% LOSS OF TOTAL ROM	OCCASIONAL	MINIMUM
FAIR	EXTENSION 30 FLEXION 110	10-30% LOSS	WITH ACTIVITY	MODERATE
POOR	EXTENSION 40 FLEXION 90	>30% LOSS	VARIABLE	SEVERE

Restriction in shoulder joint ROM of less than 5–10 degrees in any direction has been used as a criterion of a good functionalresult in previous studies of humeral shaft fractures. Only a few investigators have used shoulder scoring systems (McCormack *et al.* 2000,Scheerlinck&Handelberg 2002).

These scores take into account pain, restriction in ROM in every direction and loss of strength and thus better reveal any problem arising from the shoulder joint than ROM alone. The uninjured side was used as a control in every measurement to compensate for the wide variability of shoulder joint mobility and strength between different individuals. It is possible; however that fracture site pain interferes with pain originating from the shoulder joint. Shoulder joint pain often radiates to the deltoid insertion in the proximal humeral shaft and it may be impossible for the patient to tell the difference between these two types of pain.

The basic goal of management of diaphyseal fractures of humerus is to achieve union and restore good function. While assessing results of this study more stress was given to functional recovery and early return to the prefracturestate. Union of the fracture was judged clinically by the lack of pain or tenderness at the fracture site and by assessing serial radiograms for presence and consolidationof the bridging callus[15].

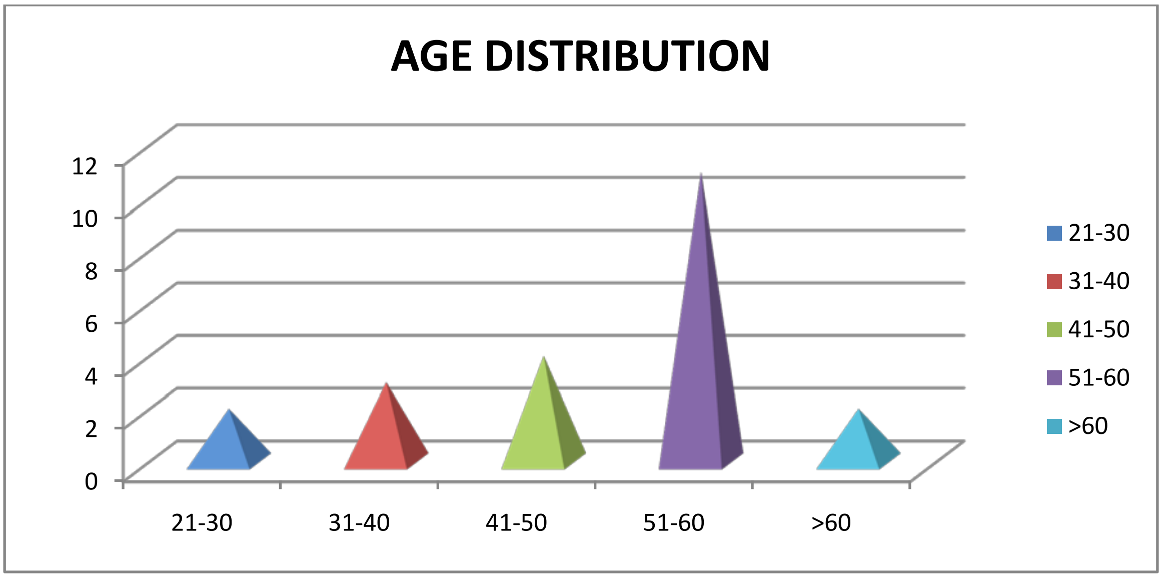
OBSERVATION AND RESULTS

AGE DISTRIBUTION

Our patients' age range from 29 to 80 with an average age of 53 years.

AGE	NO.OF PATIENTS
21-30	2
31-40	1
41-50	4
51-60	11
>60	2

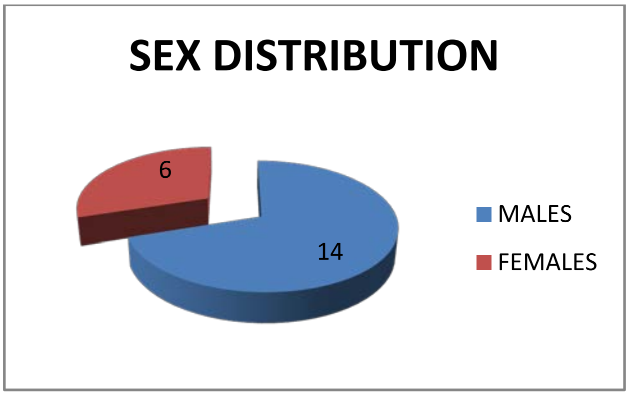
Greater number of our patients was seen in the age group of 40 -60 years



SEX DISTRIBUTION

M	14 (70%)
F	6 (30%)
TOTAL	20

Male preponderance was noticed in our series with a male to female ratio of 14:6



OCCUPATION

LABOUR	7
HOUSEWIFE	6
DRIVER	3
FARMER	4
TOTAL	20

Higher frequency of manual labourers was noticed. Though equal numbers ofhouse wives, farmers, and drivers were noted.

SIDE

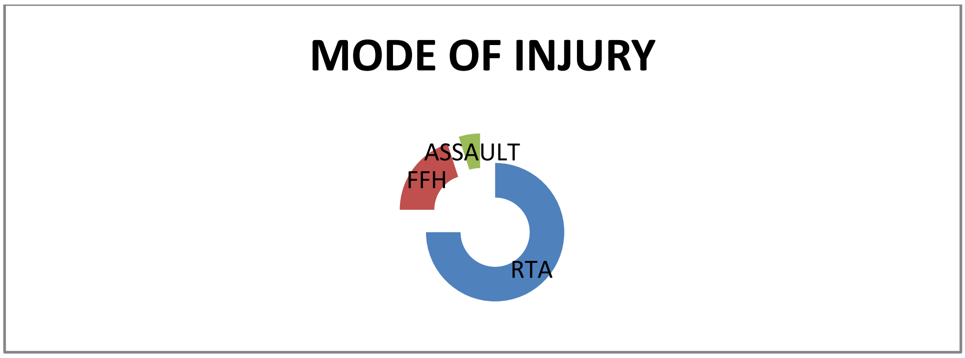
RIGHT	12 (60%)
LEFT	8 (40%)
TOTAL	20

Right side was more commonly involved than the left side

MODE OF INJURY

Road traffic accident is the most common mode of injury. It accounts for15 out of 20 cases in our series. The other 4 cases presented following a history of fall.

RTA	15
ACCIDENTAL FALL	4
ASSAULT	1
TOTAL	20

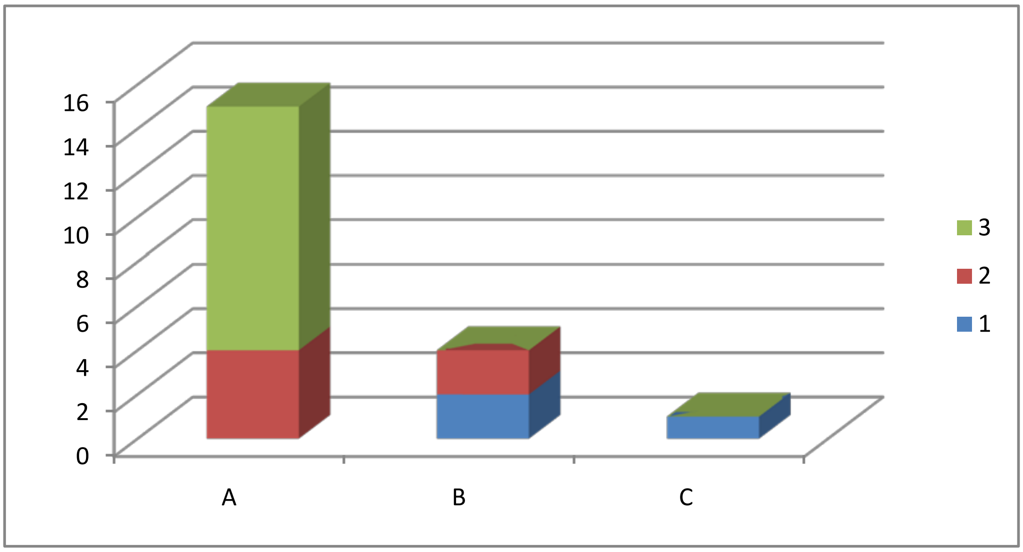


FRACTURE TYPE

The 20 cases of fractures of humeral diaphysis are classified according to the fracture pattern based on the AO/ASIF CLASSIFICATION.

Type A	15	A.1 – 0; A2 –4;A3 – 11
Type B	4	B.1 – 2; B.2 – 2
Type C	1	C.1 – 1

AO/ASIF Type A fractures are the most frequent fracture pattern noticed in our study.



SOFT TISSUE INJURY

CLOSED	18
OPEN	2
TOTAL	20

Out of 20 cases 18 cases were closed type of fractures.

ASSOCIATED INJURIES

HEAD INJURY	2
UPPERLIMB FRACTURES	3
LOWERLIMB FRACTURES	0
CHEST INJURY	1

MANAGEMENT

All the cases were immobilized with U slab till the patients were taken up for surgery. Complete preoperative evaluation was done in all the patients with regards to surgical fitness. Proper preoperative planning to decide upon the nail length and diameter was done with standard radiographs of the contralateral humerus and measurement of the arm segment.

TIME INTERVAL

The patients had to be assessed for surgical fitness. Hence a delay was noted from the time of injury to the time of surgery. In all the acute fracture cases an average time delay of 16 days were noted.

MAXIMUM	40 DAYS
MINIMUM	6 DAYS
AVERAGE	16 DAYS

PROCEDURE

The procedure was carried out in all the patients in a similar manner with regards to anaesthesia, position of the patient, approach, reduction and fixation.

REDUCTION

Closed reduction and internal fixation done in all 20 cases.

DURATION OF SURGERY

LESS THAN 1 HOUR	2
1-2 HOURS	17
MORE THAN 2 HOURS	1

Most cases took an average of one and half hours for procedure.

NAIL SPECIFICATIONS

Nail length

240MM	7
260MM	10
280MM	3

Nail diameter

6MM	13
7MM	6
8MM	1

COMPLICATIONS

Radial nerve injury

On Admission	NIL
After surgery	NIL
Recovered partially	NIL
`Recovered fully	NIL
No recovery	NIL

Functional disability

Restriction of movements in shoulder	4
Restriction of movements in elbow	0
Significant pain in shoulder	3

Shoulder stiffness

RANGE OF MOVEMENTS	NO OF CASES
Less than 10 %loss	1
10 to 30 % loss	2
More than 30 % loss	1

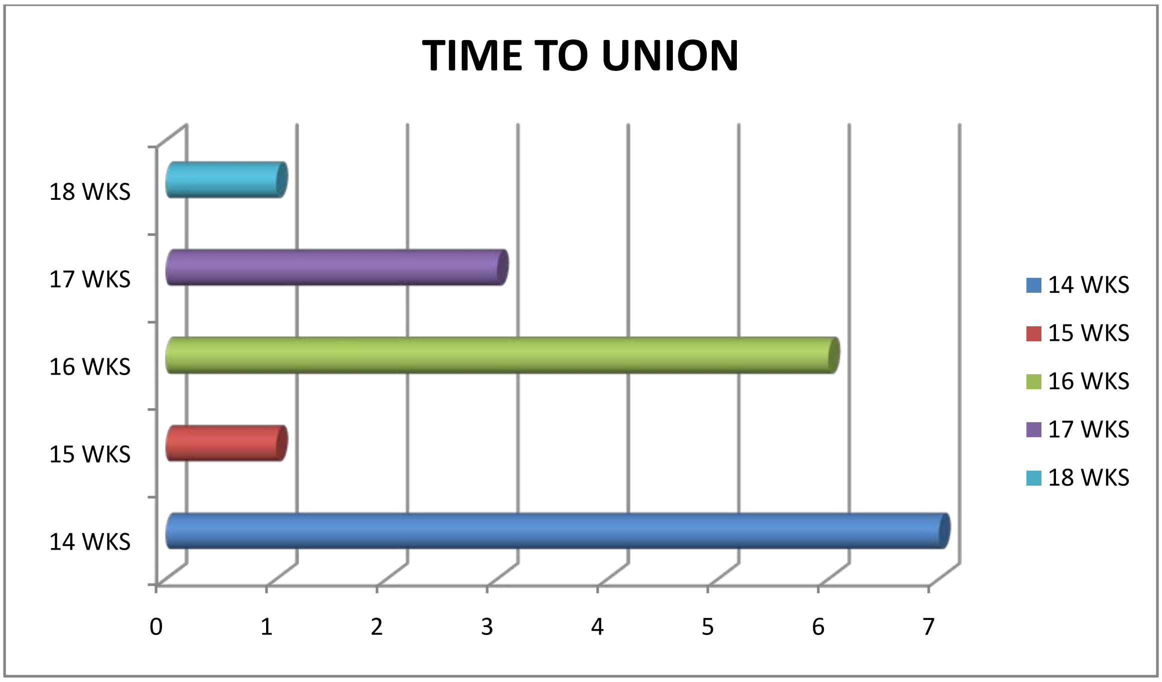
Shoulder pain

No pain	17
Mild pain	Nil
Moderate pain	2
Severe pain	1

Union

Union	No of cases
14 to 15 weeks	8
16 to 17 weeks	9
More than 18 weeks	2

Most of the cases united in 14 to 17 weeks. The average period of union is 15.4 weeks.



SUMMARY OF COMPLICATIONS

NON UNION	2	10%
DELAYED UNION	NIL	
SUPERFICIAL INFECTION	1	5%
DEEP INFECTION	NIL	
SHOULDER SYMPTOMS	4	20%
ELBOW SYMPTOMS	NIL	
RADIAL N INJURY	NIL	
AXILLARY N INJURY	NIL	
MUSCULOCUTANEOUS NERVE INJURY	NIL	
SCREW LOOSENING	1	5%
IATROGENIC COMMINUTION	NIL	
IMPLANT PROTRUSION	1	5%

FOLLOW UP

Minimum	4 months
Maximum	16 months
Average	9 months

Of the twenty cases treated in our study one case were lost for the follow up. 19 cases were followed up for an average period of 9 months (range 4- 15months). The one case that loss the follow up was fracture shaft of humerus treated with interlocking nailing complicated by nonunion.

RESULTS

POOR	1
FAIR	4
GOOD	8
EXCELLENT	7

The results were studied using the Rodriguez Merchan criteria with due consideration given to shoulder and elbow functions as far as the pain and range of movements are concerned. Only 5% of the cases got poor results and excellent results were achieved in 35% of the cases indicating the usefulness of the procedure.

CASE – I

Name	:	Sundaram
Age/Sex	:	59/male
Mode of Injury	:	RTA
Extremity	:	Left
Open/closed fracture	:	closed
Associated Injury	:	nil
AO Classification	:	A2
Time Interval between Injury and surgery	:	13 days
Nail size	:	7/260mm
Time of union	:	14 weeks
Range of Movements	:	Full
Complications	:	Nil
Rodriguez-Merchan Criteria	:	Excellent

CASE 1

PREOP

IMMED POSTOP

6 MONTHS FOLLOW UP

ONE YEAR FOLLOW UP AP

ONE YEAR FOLLOW UP LAT.

ABDUCTION

EXTERNAL ROTATION

EXTENSION

FLEXION

CASE – II

Name	:	srirangan
Age/Sex	:	29/male
Mode of Injury	:	RTA
Extremity	:	right
Open/closed fracture	:	closed
Associated Injury	:	closed# bb forearm, 4&5th metacarpal # RT
AO Classification	:	B 2
Time Interval between Injury and surgery	:	12 days
Nail size	:	6/260mm
Time of union	:	14 weeks
Range of Movements	:	Full
Complications	:	Nil
Rodriguez-Merchan Criteria	:	Excellent

CASE 2

		
PREOP	IMMED POSTOP	2 MONTHS FOLLOW UP
		
6 MONTHS FOLLOW UP	ONE YEAR FOLLOW UP	ELBOW FLEXION
		
ADDUCTION	ABDUCTION	EXT ROTATION

CASE – III

Name	:	Vijaya
Age/Sex	:	40/female
Mode of Injury	:	Accidental fall
Extremity	:	left
Open/closed fracture	:	closed
Associated Injury	:	nil
AO Classification	:	A 3
Time Interval between Injury and surgery	:	16 days
Nail size	:	6/240mm
Time of union	:	14 weeks
Range of Movements	:	Full
Complications	:	Nill
Rodriguez-Merchan Criteria	:	Excellent

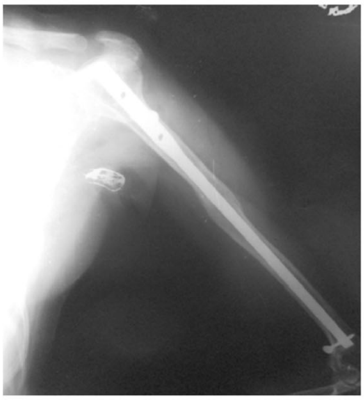
CASE 3

PREOP

IMMED POSTOP

1M FOLLOWUP

3M FOLLOWUP



10M FOLLOWUP

ABDUCTION

ADDUCTION

EXT ROTATION

INT ROTATION

CASE – IV

Name	:	Viji
Age/Sex	:	29/female
Mode of Injury	:	Accidental fall
Extremity	:	right
Open/closed fracture	:	closed
Associated Injury	:	nil
AO Classification	:	A 2
Time Interval between Injury and surgery	:	13 days
Nail size	:	6/240mm
Time of union	:	14 weeks
Range of Movements	:	Full
Complications	:	Nil
Rodriguez-Merchan Criteria	:	Excellent

CASE 4


PREOP


IMMED POSTOP


1MONTH FU


SIX MONTHS FOLLOW UP AP


SIX MONTHS FOLLOW UP LAT.


EXT ROTATION


ABDUCTION


ADDUCTION


INT ROTATION

CASE – V

Name	:	Rathnivel
Age/Sex	:	58/male
Mode of Injury	:	RTA
Extremity	:	left
Open/closed fracture	:	Grade I open
Associated Injury	:	# neck of scapula, # bb forearm Left
AO Classification	:	A 3
Time Interval between Injury and surgery	:	40 days
Nail size	:	6/240mm
Time of union	:	17 weeks
Range of Movements	:	Restricted
Complications	:	superficial infection and shoulder pain
Rodriguez-Merchan Criteria	:	Fair

CASE 5

PREOP

IMMED POSTOP AP

IMMED POSTOP LAT.

4 MONTHS FOLLOW UP

8 MONTHS FOLLOW UP

ABDUCTION

ADDUCTION

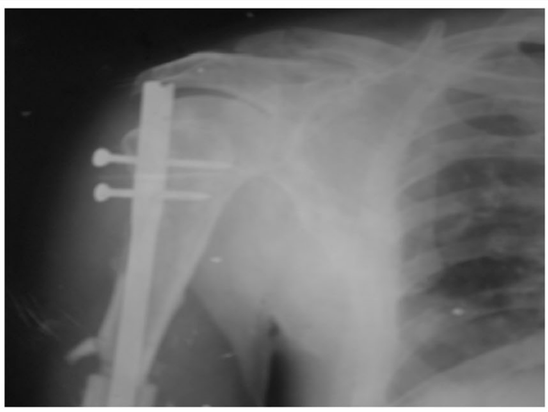
EXT ROTATION

INT ROTATION

COMPLICATIONS

NONUNION

NONUNION



NAIL PROTRUSION

PROXIMAL SCREW LOOSENING

SHOULDER STIFFNESS

DISCUSSION

There are several modalities for the management of diaphyseal humeral fractures. Isolated, low energy humeral shaft fractures usually can be treated satisfactorily with non-operative methods but operative stabilization often is necessary for acute, high energy humeral shaft fractures to improve healing, fracture alignment, and functional results[9].

Although plate osteosynthesis can afford a rigid fixation and good functional recovery, its disadvantages like requiring a wide surgical exposure and more time when compared with intramedullary fixationhas been reported[15]. Interlocking nail gives rotational stability, decreases the need for postoperative bracing and allows early mobilization of the extremity[6]. Locked intramedullary nails usually can be inserted using closed techniques, avoiding the extensive soft tissue dissection required for plating.

A series of 20 cases of fracture shaft of humerus treated by antegrade intramedullary interlocking nailing were studied. The results of the use of intramedullary nailing for the diaphyseal fractures of the humerus have been mixed, with some studies showing good outcome and some others poor outcome. In most studies a significant percentage of patients do not return for follow up once the limb is functional and painless[43]. Non-union and functional disability of the shoulder is the most common complaints in most patients postoperatively.

There was a bimodal distribution of fractures with a peak in young, primarily male patients in the 21 to 40 age group and a second peak in older females 60 to 80 years old as shown by Tytherleigh-Strong et al 1988. In our study most of the patient's age was between 40 to60 years.

Also high energy trauma was responsible for the majority of injuries in young patients, and this is the population that most of the orthopaedic literature focuses on[4].

Most of the cases in our present study (75%) were following a road traffic accident indicating the enormous implications this epidemic on the health care resources. 6 cases had associated injuries in our study.

In our series of 20 cases careful history taking and thorough clinical examination as per the set standard protocols helped us in proper selection of cases and meticulous preoperative planning resulting in lesser complications.

An average delay of 16 days was noted in our case series, which was due to the delay in getting the patient surgically fit. In our study, we encountered 75% Type A fractures, 20% Type B fractures and 5% Type C fractures based on AO classification system. 90% of cases were closed injuries while only 10% were open injury (Grade I Gustilo Anderson). It is comparable to Tytherleigh-Stronget al 1988findings.

The basic goal of management of diaphyseal fractures of humerus is to achieve union and restore good function.

Union of the fracture was judged clinically by the lack of pain or tenderness at the fracture site and by assessing serial radiograms for presence and consolidation of the bridging callus.

In our series union was noted in 18 of the 20 cases (90%) of fracture humeral diaphysis. Ingman and Waters in 1994 reported union in 95%.

Ikpeme in 1994 published 100% union in his study[20]. Crates and Whittle, in 1998 had a 94.5% unionrate[10]. Our study is comparable to other international studies, which mention a union rate of 90-100%[5, 9, 10, 28].On the other hand plate osteosynthesis gives a fracture union rate of

93 – 100%[15, 31, 42] while functional bracing for the humerus show a union rate of 97-100%[30, 41, 42].

The average time for union in our series was 15.4 wks. (14 – 18) wks for all acute cases. This is comparable to series by Rommene et al, 1998, which showa union time of 12.3 wks to 16 wks[1, 11, and 22]. This is in comparison to compression plating where the union is achieved in 16 to 26wks[9, 27.] On the other hand various studies on functional bracing show an average time of 11.5 wks for the evidence of clinical and radiological union[41].

Faster union rate was noticed when closed reduction was done rather than open reduction. Static locking system when used along with the compression of the fracture site, which was achieved by back slapping the nail after distal locking screw insertion, resulted in a better union rate.

In our study, 10 %(2) cases showed nonunions at the end of24 weeks. This is comparable to study of Rommene et al in 1998[38] which show 7.4% non-union. One case of segmental nonunion underwent the second surgical procedure in the form of bone grafting and fracture united at around 36 weeks. The other case of non-union was lost for follow up when we advised bone grafting.

In treating case of non-union of humeral diaphyseal fractures following locked intramedullary nailing better results can be achieved with bone grafting alone with possible fracture site compression with the help of reinserting the locking screws[25]. Exchange nailing for humeral nonunions have been a rare necessity.

All our operative procedures achieve good alignment of the fractured bone while the same cannot be expected with any of the available conservative methods of management. As the nail is used as an internal splinting device there was no evidence of mal alignment of the fracture.

The distraction of the fracture after IM nailing occurred in only one case in this study and which ended up in nonunion. Also the humerus is a hanging bone and gravity tends to distract fracture fragments.

Distraction may have been due to a simple technical error or the anatomic limitations of humerus. The medullary canal begins narrowing about 3 cm above the olecranon fossa and this may cause jamming of the nail tip and contribute to distraction at the site of the fracture during nailing[29]. To avoid distraction of the fragments, a meticulous operative technique must be used.

Previous studies show that Intramedullary nailing should be avoided in humerus with narrow medullary canals[24] .However, the nails used in our series range from 6mm to 8mm. This is probably due to the small profile of humerus in the population studied in our series.

The introduction of a large-diameter intramedullary nail into a fractured humerus can lead to comminution of the existing fracture or insertion site. With most recent nail designs being offered in small diameters, iatrogenic comminution of the shaft has been even rarer. With increased awareness of this complication, the incidence in our series has been nil considering that no iatrogenic comminution has occurred.

Stress fractures at the end of implant have not been observed in our series. Fractures at the end of implant are rarely seen with intramedullary nailing in the lower extremity. In humerus the tip of the intramedullary implant ends in diaphyseal, rather than metaphyseal, bone. The combination of a long rigid implant ending in diaphyseal bone and adjacent cortical holes drilled for locking screws is biomechanically disadvantageous[25]. Careful technique is critical ,especially avoidance of drilling cortical holes that “miss” the locking holes and leaves an unfilled cortical defect.

The prevalence of radial nerve injuries in humeral shaft fractures was 11.8 percent[5, 9]. Risk factors for radial nerve injury included transverse and spiral fracture patterns as well as fractures of the middle and middle-distal fifths of the diaphysis[9]. In our series none of the cases presenting initially with nerve injury at the outset were included to accurately assess the incidence of iatrogenic nerve injuries and also none of the cases (0%) developed post operative radial nerve injury. Ingman and Waters in 1994 published ((0%) no iatrogenic nerve palsies[5].

Crates and Whittle in 1998[10] (2.7%).Our study corresponds to the international studies on locked nailing which show a rate of iatrogenic nerve injury between 0-3%.[5,9,10] This compares favourably with plate osteosynthesis, which consistently has a higher rate of radial nerve injury[5]. Number of radial nerve palsy is significantly lower in intramedullary nailing than in plating.

The superiority in this aspect is attributable to the closed technique of reduction and internal fixation, which prevents the exposure of the radial nerve. All the cases in our series were fixed with closed interlocking nailing. The one case with non-union was addressed with open reduction and bone grafting with antero lateral approach. This has accounted for the nil incidence of radial nerve palsy.

Even in cases of iatrogenic nerve palsy reported in the literature90 percent of these palsies are neurapraxias and the patient recovers spontaneously. The onset of recovery usually occurs within 3 months but can be delayed up to 6 months. The risk for injury to the radial nerve usually is during reaming and nail insertion. Somatosensory evoked potential (SSEP) monitoring during closed humeral nailing has been reported to be useful in accurately identifying neurologic problems that necessitate a change in the surgical plan[5].

The potential for radial nerve injury can be minimized during closed nailing of the humerus by ensuring accurate reduction of the fracture (no gap) before passage of the reamers or the nail and by opposed to the bone. Radial nerve injury can be minimised by avoiding excessive traction and fracture manipulation during the surgicalprocedure[13].

In general, however, proximal locking with a standard locking jig sleeve-trocar system appears safe if performed in a lateral-to-medial direction within 5 cm of the edge of the acromion to avoid injury to the axillary nerve. Some smaller branches of the nerve which are present along the lateral surface of humerus when inadvertently injured may explain some of the shoulder pain and dysfunction seen after antegrade nailing.

Although it is necessary to engage the medial cortex to enhance screw stability, overpenetration should be avoided because of possible damage to the axillary nerve. However in our series none of the cases presented postoperatively with axillary nerve palsy.

All nails in our series were locked with one or two distal locking screws for stability. Given the proximity of important nervous structures, their variable position, the varying position of the tip of the nail, and the lack of any clearly visible or palpable landmarks or “safezones,” percutaneous insertion of distal locking screws through “stab”incisions are dangerous.

The median nerve, musculocutaneous nerve (and lateral cutaneous branch), and brachial artery are at risk from the anteroposterior approach[1]. Difficulty was noticed in the insertion of the distal locking screw due to the sloping contour of the anterior surface of the distal humerus. This was further complicated by the muscle bulk of the biceps and brachialis, which interfere with the distal locking mechanism. Use of image intensifier control is essential and screws should be inserted under direct vision through incisions large enough to protect local nerves and vessels.

Shoulder stiffness and functional compromise can occur with antegrade intramedullary nailing. In our study 4 of 20 cases (20%) had shoulder problem which is comparable to Ikpeme, 1994 et al[20] (20%) and Crates and Whittle in 1998[10](13.7%).

In our series, 16 of the 20 cases (80%) of the fracture of shaft of humerus attained near normal range of motion of the shoulder joint. It was observed that the movements and the functional ability of the shoulder depended upon the amount of consolidation at the fracture site, and the rehabilitation programme used. These findings are comparable to those of other studies, which show a 90 – 95 % return of shoulder tonormalcy[5,10,28]

Proximal protrusion or inadequate insertion of nails may cause

subacromial impingement and shoulder pain. Inadequate insertion of nail in one case in our present series ended with severe shoulder joint symptoms. The impingement at the shoulder joint can be overcome by impacting the nail deep into the bone before locking the nail. Careful repair of the rotator cuff incision and deltoid split was done in all the cases to avoid shoulder pain, restriction of movements or weakness[35].Proximal locking screws protruding into the deltoid muscle or the branches of axillary nerve may be a major source of shoulder pain[21]. Inour study one case(5%) of proximal screw loosening cause shoulder pain.

In our series none of the case developed restricted elbow movements. In antegrade insertion technique since the triceps mechanism is least involved there was no restriction in the range of motion of the elbow.

In our study one case (5%) developed superficial wound infection that healed by antibiotics, which is also consistent with other international studies[28]. This can be attributed to the lesser exposure time, smaller incision and lesser bulk of implant being used.

Post op mobilization of the shoulder and elbow was very critical in attaining the amount of movements of the shoulder. Better results were noted in more educated rehabilitation program, with an active involvement of the patient.

Rodriguez and Merchan criteria was used to assess the functional recovery in all the patients in the postoperative period. The results of the criteria correlated well with functional ability of the patients. It takes into consideration all aspects of the fracture complications including shoulder range of movements, elbow movements, pain in the shoulder and the functional disability.

Antegrade interlocking humeral nailing does not require extensive soft tissue dissection, infrequently requires bone grafting, does not require external immobilization, and may be more suitable for comminuted and segmental fracture patterns than plating or flexible nailing techniques and also in poly trauma cases[6].

CONCLUSION

Locked intramedullary nailing is a novel treatment option for diaphyseal fractures of the humerus. It is ideal in treating diaphyseal fractures of the humerus in patients when other treatment methods are likely to fail, like those with osteoporosis, severely comminuted segmental fractures and polytrauma where reduction in operating time and early rehabilitation are the primary objective.

The concept of biological fixation in terms of unreamed nailing, closed reduction, static locking, and fracture site compression promotes early and adequate fracture union.

The problem of shoulder impingement and peri-arthritis shoulder can be reduced by placing the nail flush with the bone at the entry site, adequate repair of the rotator cuff, and by educated motivated rehabilitation program, which promotes good functional outcome.

Despite some methodological limitations, this study gave useful information and solutions to handling of specific problems associated with antegrade IM nailing of humeral shaft fractures.

Antegrade nailing should be avoided in patients with preexisting shoulder pathology or those who will be permanent upper extremity weight-bearers (para- or quadriplegics).

Locking of the nails should be done both proximally and distally with screws. Use a mini-open technique for distal locking.

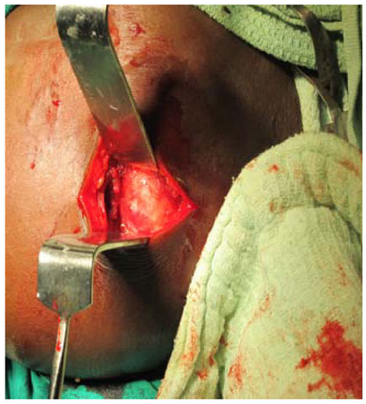
Intramedullary nailing in narrow-diameter canals should be avoided. Excessive reaming is not desirable in the humerus.

Nail length should be chosen carefully and it may be errored on the shorter side rather than the longer side. Do not distract the fracture site by trying to impact a nail that is excessively long.

Locked intramedullary-nailing is an effective and safe alternative for the treatment of diaphyseal humeral fractures. It is suitable for treatment in patients with osteoporosis, pathological fractures, polytrauma and associated neurovascular injuries. It helps in providing early rehabilitation and lessens the morbidity.

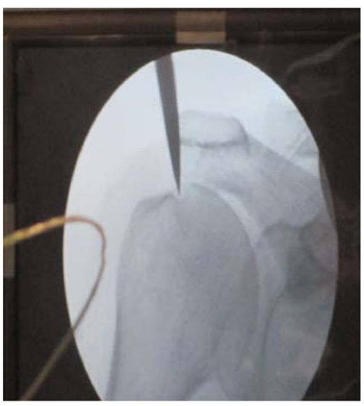
PROCEDURE

POSITION



APPROACH

APPROACH



ENTRY POINT

ENTRY POINT

GUIDE WIRE INSERTION

REAMING

REAMING

NAIL INSERTION

PROCEDURE

DISTAL LOCKING

DISTAL LOCKING

PROXIMAL LOCKING

PROXIMAL LOCKING

PROXIMAL LOCKING

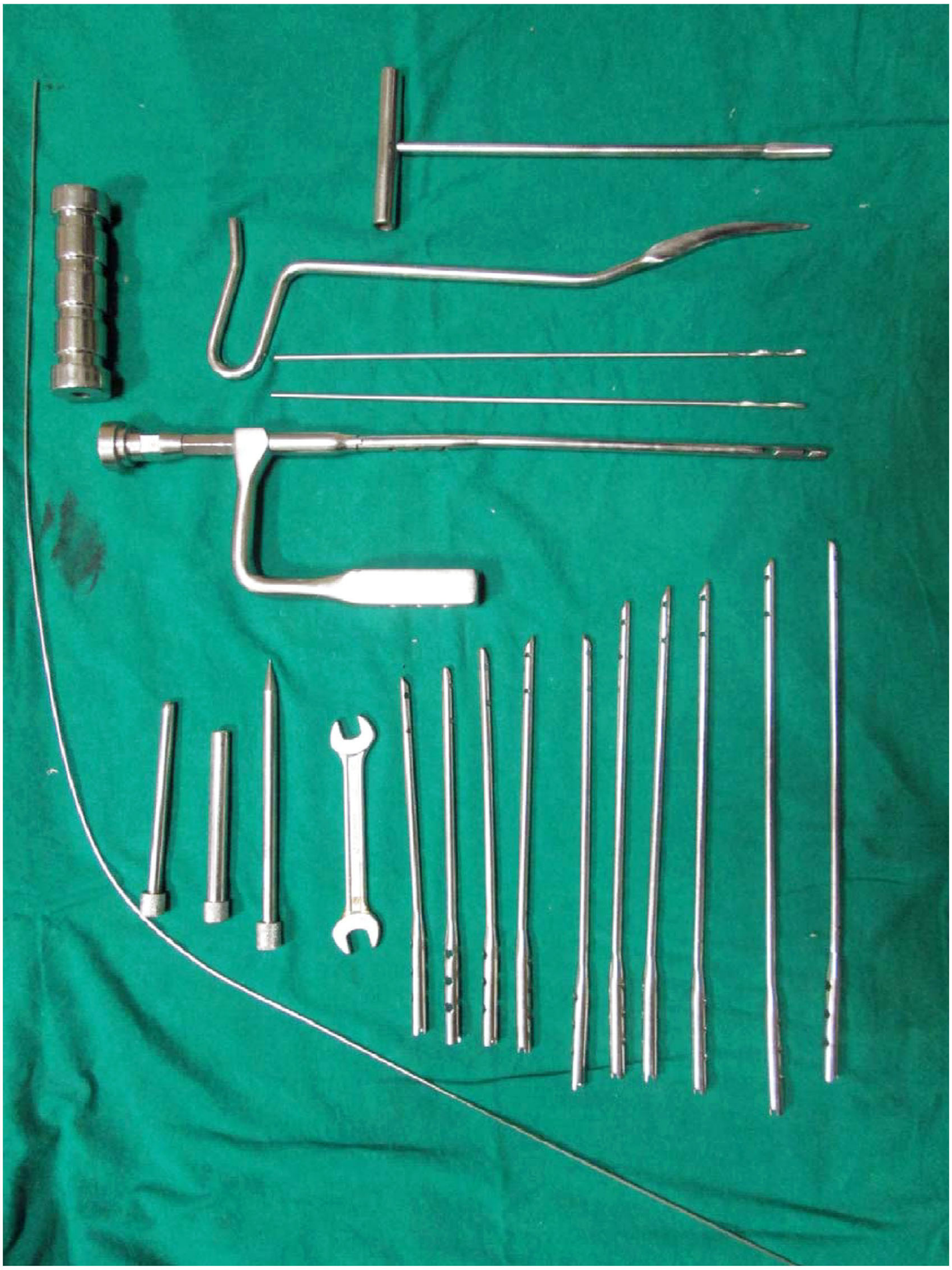
PROXIMAL LOCKING

POSTOP XRAY

POSTOP XRAY

CLOSURE

INSTRUMENTATION



BIBLIOGRAPHY

1. Aprachioglu MO, Pehlivan O, Akmaz I, Kiral A, Oguz Y et.al. Interlocking intramedullary nailing oh humeral shaft fractures in adults. Acta. Orthop. Traumatol. Turc. 2003; 37:19-25.

2. Balfour GW, Mooney V, Ashby ME diaphysial fractures of the humerus treated with ready-made brace. Journal of bone and joint surgery.1982 (B); 64: 11-13.

3. Bell MJ, Beauchamp CG, Kellam JK et.al. Results of plating of shaft of humerus fractures in patients with multiple injuries: the sunny broke experience. Journal of bone and joint surgery.1986 (A); 68: 960-70.

4. Bleeker WA, Nijsten MW, ten Duis HJ et al Treatment of humeral shaft fractures related to associated injuries: a retrospective study of 237 patients. Acta. Orthop. Scand.1991; 62: 148-53.

5. Blum J, Rommens PM, Janzing H et.al. Unreamed humeral nailing, biological osteosynthesis of the upper arm. Acta. Cirarg. Belg. 1997; 97:184 9.

6. Brumback RJ, Bosse MJ, Poka A, et.al. Intramedullary stabilization of shaft of humerus fractures in patients with multiple traumas. Journal of bone and joint surgery 1986 (A); 68: 960-70.

7. Caldwell JA et.al. Treatment of fractures shaft of the humerus by hanging cast. Surg. Gynaecol. Obstet. 1940; 70:421-5.

8. Camedane P, Nade S et.al. Fracture bracing of the humerus. Injury. 1992; 23: 245-8.

9. Chapman JR, Henley MB, Agel J, Benca PJ. Randomized prospective study of humerus shaft fractures fixation: intramedullary nailing versus plating. J. Orthop. Trauma.2000; 14: 162-6.

10. Crates J, Whittle AP Ante grade interlocking nailing for acute humeral shaft fractures. Clinic.orthop.1998; 350: 40-50.

11. Crolla RM, de Vries LS, Clevers GJ: Locked Intramedullary nail for humeral shaft fractures. Injury 1993; 24: 403-6.

12. Fernandez FF, Matschke S, Hulsenbeck A, Egenolf M, Wentzensen A. five years clinical experience in unreamed humeral nail in humerus shaft fractures. Injury 2004; 35 (3); 264-71.

13. Flinkkila T, Hyvonen P, Lakovaara M, Linder T, Restinemi J, Hamaleinen M Intramedullary nailing of shaft of humerus .a retrospective study of 126 cases. Acta. Orthop. Scand.1999; 70: 133-6.

14. Habernek H, Orthner E, locked nail for fractures of the humerus. Journal of bone and joint surgery. 1998(B); 80: 557.

15. Hagelmaier C, von Aproth B, Plate osteosynthesis of diaphysial humerus fractures Indications- risks- results. Aktulle Traumatol. 1993; 23: 36-42.

16. Hall RF, Pankovich AM et.al. Ender nailing of acute fractures of the humerus. A study of closed fixation of humerus by intramedullary nailing without reaming. Journal of bone and joint surgery.1987 (A); 69: 558-67.

17. Henley MB, Chapman JR, Claudi BF. Closed retrograde Hackethal nail stabilization of humeral shaft fractures. J. Orthop. Trauma. 1992; 6: 18-24.

18. Holms CL et.al. Management of humeral shaft fractures; fundamental non-operative techniques.Clinic.orthop.1970; 71: 132-9.

19. Hunter SG et.al. Closed treatment of fractures of the shaft of the humerus. Clinic. Orthop 1982; 164: 192-8.

20. Ikpeme, JO. Intramedullary interlocking nailing for humeral fractures: experiences with the Russell-Taylor humeral nail. 1994; 25: 447-455.

21. Klenermann L et.al. Fracture shaft of the humerus. . Journal of bone and joint surgery.1966 (B); 48:105-11.

22. Kropfl A, Naglik H, Neiderweiser B, Hertz N et.al. Unreamed antegrade humerus interlocking nail. Unfallchirurg. 2000; 103(5): 348-54.

23. Leibergall M, Jaber S, Lante M Ender nailing of acute fractures in multiple injuries. Injury 1997; 28: 577-80.

24. Linn J, Hou SM, Inoue N, Edmund YSC, Hang YS. Anatomical consideration of locked humeral nailing. Clinical Orthopaedics and related research.1999:247-54.

25. Linn J, Hou SM, Hang YS. Treatment of humeral shaft delayed unions and non-unions with humeral interlocking nails. J. Trauma.2000; 48:695-703.

26. Maatz W, Lentz W, Arcu H, intramedullary nailing and other intramedullary osteosynthesis Saunder's; 1986.

27. Martinez AA, Cuenca J, Herrera A, treatment of humeral shaft nonunion. Plating versus nailing. Arch. Orthop. Trauma. Surg. 2004; 124:92-5.

28. Mauch J, Rennu N, Rikli D, Intramedullary nailing of humeral shaft fractures. An initial experience with unreamed humeral nail. Swiss surgery 2000; 6:299-303.

29. Muller MV. Manual of internal fixation AO/ASIF. 1991

30. Ostermann et.al.

31. Paris H, Tropiano P, Clouet D'orval B, Chaudet H, Poitout DG. Fractures of the shaft of humerus, systematic plate fixation. A. Rev. Chir. Orthop. Reparatrice. Appar. Mot. 2000; 86: 346

32. Peter LW, Warwick R Dyson M, Bannister LN, et.al. Gray's textbook of anatomy; 37:1989.

33. Peter RE, Hoffmeyer P, Henley MB et.al. Treatment of humeral diaphysial fractures with Hackethal stacked nailing, a report of 33 cases. J. Orthop. Trauma. 1992; 6: 14-7.

34. Pohler, Strumann F. Characteristics of stainless steel. . Manual of internal fixation AO/ASIF 1991

35. Reimer BL, Butter field SL, D'Ambrosia R. Seidel Intramedullary nail in humeral diaphysial fractures, a preliminary report. Orthopaedics 1991; 14: 239-46.

36. Rheinlander IW, Nelson LL et al vascular and histological response of diaphysial cortex to experimental medullary reaming. Journal of bone and joint surgery .1973; 55(A): 1767.

37. Rheinlander FW Effects of medullary nailing on the normal blood supply of diaphysial cortex. Clinical orthopaedics and related research. 1998; 5-18.

38. Rommens PM. Principles of fracture management AO/ASIF 2000.

39. Rosen H treatment of non-union and pseudoarthrosis of humeral shafts. Ortho. Clinics of north America.1990; 21(4): 725-42

40. Ruedi. Manual of internal fixation AO/ASIF 1991; 2

41. Sarmiento, Zagaroski JB, Zych DO, Latta LL, Capps CA et.al. Functional bracing for treatment of fractures of the humeral diaphysis. Journal of bone and joint surgery. 2000(A); 476-86.

42. Seibert CH, Heinz BC, Hofler HR, Hansis M. Plate osteosynthesis management of humeral shaft fractures. Unfallchirurg.1996; 99:106-11.

43. Scherlink T, Handelberg F et.al. Functional outcome after intramedullary nailing of humeral shaft fractures; a comparison between retrograde Marchetti-Vicenzi nail and unreamed antegrade humeral nail. J. Trauma.2002; 52(1): 60-71.

44. Thakur AJ. Elements of fracture fixation.1997; 1:81-104,Churchill – Livingstone.

45. Wallny T, Sagebiel C, Westermann K. Comparative results of bracing and interlocking nailing in the treatment of humeral shaft fractures. Int. Orthop.1997; 21: 374-9.

46. Weller S, Hontsch D Manual of internal fixation AO/ASIF. 1991

47. Wentzensen et.al. Zagaroski JB, Latta LL, Zych GA et.al. Diaphysial fractures of the humerus a treatment with prefabricated brace. Journal of bone and joint surgery.1988 (A); 70:607-10

PROFORMA

NAME:	AGE/SEX:
I.P.NO:	OCCUPATION:
DATE OF INJURY:	DATE OF SURGERY:

MODE OF INJURY:

SIDE OF INJURY:

OPEN/CLOSED FRACTURE:

AO CLASSIFICATION:

ASSOCIATED INJURY:

PROCEDURE DONE:

CLOSED INTERLOCKING NAIL

NAIL DETAILS:

1. Length and Diameter
2. Proximal and Distal locking

COMPLICATIONS:

BONE GRAFTING:

TIME FOR UNION:

SECONDARY PROCEDURE:

FUNCTIONAL OUTCOME:

MASTER CHART

S. NO	NAME	AGE	SEX	MODE	SIDE	AO	TYPE	ASSOCIATED INJURY	INTERVAL DAYS	NAIL	SHOULDER PAIN	NERVE INJ	NONUNION	BONE GRAFTING	SHOULDER ROM	INFECTION	UNION WKS	FOLLOW UP MONTHS	RESULT
1	Chinnasamy	56	M	RTA	Right	A3-2	Closed		22	7x260	Nil	nil	no	NIL	Free	NO	16	15	Good
2	Sundaram	59	M	RTA	Right	A2-2	Closed		13	7x260	Nil	nil	no	NIL	Free	NO	14	13	Excellent
3	Srirangan	29	M	RTA	Right	B2-2	Closed	#bb forearm, 4-5th mc # R	12	6x260	Nil	nil	no	NIL	Free	NO	14	13	Excellent
4	Ponniyammal	60	F	RTA	Right	A3-2	Closed		22	7x260	Nil	nil	no	NIL	Free	NO	16	12	Good
5	Pappati	65	F	RTA	left	A3-2	Closed		19	7x260	Nil	nil	no	NIL	Free	NO	16	11	Good
6	Gurunathan	55	M	RTA	left	B1-3	Closed		23	6x280	Nil	nil	no	NIL	Free	NO	17	10	Good
7	Vijaya	40	F	FALL	left	A3-2	Closed		16	6x240	Nil	nil	no	NIL	Free	NO	14	10	Excellent
8	Abdulla	58	M	RTA	left	C2-1	Closed		25	6x260	Nil	nil	yes	YES	Free	NO	36	16	Fair
9	Ameer	31	M	RTA	left	A3-1	Closed		13	6x260	Nil	nil	no	NIL	Free	NO	16	10	Good
10	Mani	42	M	RTA	Right	A3-2	Closed	# radius,cmc dislocation R	14	6x240	Nil	nil	no	NIL	Restricted	NO	17	10	Fair
11	Viji	29	F	FALL	Right	A2-2	Closed		13	6x240	Nil	nil	no	NIL	Free	NO	14	6	Excellent
12	Rathinavel	58	M	RTA	left	A3-3	Open I	# scapula L, #BB forearm L	40	6x240	MOD	nil	no	NIL	Free	YES	17	8	Fair
13	Ammasi	60	F	FALL	Right	A2-2	Closed		6	6x240	Nil	nil	no	NIL	Free	NO	18	8	Fair
14	Perumal	60	M	ASLT	Right	A3-1	Closed		11	7x280	Nil	nil	no	NIL	Free	NO	16	6	Good
15	Chinnasamy	80	M	RTA	Right	A3-2	Closed		15	7x280	Nil	nil	no	NIL	Free	NO	15	5	Good
16	Sembadatchi	60	F	RTA	Right	A3-2	Closed		32	6x240	SEVERE	nil	yes	NIL	Restricted	NO	lost follow	6	Poor
17	Marimuthu	50	M	FALL	left	B2-3	Closed		10	6x240	Nil	nil	no	NIL	Free	NO	14	4	Excellent
18	Madeswaran	59	M	RTA	Right	A3-1	Open I		6	8x260	Nil	nil	no	NIL	Free	NO	14	4	Excellent
19	Annamalai	55	M	RTA	Right	A2-2	Closed		7	6x260	MOD	nil	no	NIL	Restricted	NO	16	14	Fair
20	Settu	46	M	RTA	left	B1-2	Closed		6	6X260	Nil	nil	no	NIL	Free	NO	14	4	Excellent